RENEWABLE ENERGY: AN OPPORTUNITY FOR THE SOUTH AFRICAN SUGAR INDUSTRY?

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Abstract

In the South African sugar industry, both co-generation and the production of fuel alcohol are considered to be uneconomical. Although this is probably true at present, it might change in the near future due to changing market opportunities, environmental considerations, technological developments and an increasing demand for energy. The South African Government targets 10 000 GWh renewable energy by 2013, to be produced mainly from biomass, wind, solar and small-scale hydro. The renewable energy is to be utilised for power generation and non-electrical technologies such as solar water heating and bio-fuel. This presents an opportunity for the South African sugar industry in terms of value addition and diversification and reduces its exposure to the world sugar market. To seize this opportunity the industry has to be pro-active both in laying the political and technical foundations. This paper looks at the possible prospects of renewable energy for the South African sugar industry.

Introduction

Although it produces some by-products, the South African sugar industry has sugar as its core business. With sugar as its only significant commercial product the industry is exposed to fluctuations in the world sugar market. An over-supply of sugar has caused sugar profits to dwindle and many industries are considering by-products to increase their earnings (Paturau, 1989). However, most by-products have only a limited market with a small demand. Energy is exceptional, requiring large volumes in a growing market. In addition, in the domestic energy market, a local supplier has a comparative advantage. Although the production of bio-energy is technically feasible, the economics have prevented the industry from entering this market. This is, however, changing fast with the increasing real cost of energy and advances in technology. It is believed that there is an opportunity for the South African sugar industry to supplement its revenue with income from co-generation and fuel alcohol in the foreseeable future.

Drivers for renewable energy

The current interest in renewable energy from sugarcane results from a worldwide concern about the use of fossil fuels and a low world sugar price.

The use of fossil fuels

There is general agreement among politicians, scientists and industrialists, that the present use of fossil fuels to satisfy the world energy requirements is both undesirable and unsustainable. In line with international trends the South African Government is looking for alternative energy sources to meet the increasing energy demand. It is targeting 10 000 GWh of renewable energy by 2013 (Anon, 2002). The following energy sources have been identified (Table 1).

Presently most of these renewable energy technologies are uneconomical and require financial support which can be in the form of carbon credits, green energy certificates, tax rebates or Government subsidies. The South African Government is currently investigating the optimum mix of technologies to meet the 10 000 GWh target at the least cost to society (Anon, 2003a). At the same time the Government is putting in place a legislative framework to attract independent power generators (Purchase, 2003).

Table 1. Potential sources of renewable energy in South Africa.

Source	Energy (GWh)	Ave cost (c/kWh)
Biomass – wood and pulp	110	19
Landfill gas	598	22
Mini-hydro	9 245	26
Biomass – bagasse[1]	5 891	34
Solar water heating[2]	6 940	36
Wind energy	93 191	38
Bio-fuels (ethanol and bio-diesel)	~	~

[1]Gasification Combined Cycle excluded.
[2]Retail price

At Government level the interest in renewable energy is driven by:

- The protection of existing employment and/or the creation of new employment. This is of particular relevance to the sugar industry, which stands to lose jobs due to a depressed world sugar economy. Employment within the industry is approximately 85 000 jobs. Direct and indirect employment is estimated at 350 000 people, and about one million people are dependent on the sugar industry (Anon, 2003b).
- A means of reducing the negative environmental impact associated with the use of fossil fuels (green house gasses (GHG)). Increasing green house gasses are expected to lead to global warming, resulting in the extinction of species, the flooding of coastal population centres and dramatically altered climate and weather patterns. In response to the Kyoto protocol some large countries have recently decreed their support and provided incentives for renewable energy.
- The need for energy security in the face of depleting fossil fuel reserves. Although South Africa has an abundance of coal it is expected that the price of fossil fuel, including coal, will rise dramatically in the foreseeable future as a result of increasing demand, together with diminishing supply.

The world sugar market

While sugar prices are highly variable on a year-to-year basis, there has been a long-term downward trend for over 200 years in real terms (Keating *et al.*, 2002). Between 1988 and 1998 the raw sugar price averaged 11 US c/lb, with an all time low of 5 US c/lb in 1999. Over that same period the world average cost of production exceeded the average world sugar price and many producers had to rely on financial support. This support could be in the form of preferential markets, export subsidies or protected domestic markets. Even with this support many high cost producers found themselves in serious trouble. This unhealthy state of affairs raises the question about factors shaping the future world sugar economy.

This question is dealt with in various publications (Koo and Taylor, 1999; Hannah, 2000; Baron, 2002) and some of the factors are given below:

- The most fundamental economic driver of the world sugar economy is consumption growth (about 2% per year over the last decade to reach 130.9 million tons of sugar in 2000). The underlying drivers are population growth and increasing personal wealth in developing countries, particularly Africa and Asia. In 2000 the sugar consumption per capita was: South America 46.0 kg, Central America 43.5 kg, Europe 37.0 kg, North America 34.1 kg, Africa 14.7 kg and Asia 13.0 kg (Hannah, 2000). This suggests a substantial increase in sugar consumption in the developing countries over the coming decade.
- Brazil's production for 2003/04 is estimated to be a record 350 million tons of cane with a production of 24 million tons of sugar and 14.4 billion litres of fuel ethanol (Anon, 2004). Brazil's sugar export is 14.1 million tons, exceeding 30% of the total world export market. The sheer size of the Brazilian sugar industry, its potential to shift between sugar and alcohol production and the fact that Brazil is one of the lowest cost producers of sugar (5.5 US c/lb) puts it in a controlling position in the world sugar market. It is suggested that the future world sugar price is likely to be set by Brazil at about 8 US c/lb (Hannah, 2000).
- High fructose corn syrup (HFCS) and artificial sweeteners are the main competitors of sugar. The principal producers of HFCS are North America and Japan. The world average cost of production of HFCS is estimated by Landell Mills at 13 US c/lb (as quoted by Hannah, 2000). It is believed that as long as the sugar price remains below this level there will be no significant increase in HFCS production. Artificial sweeteners are, however, cheap and it is likely that they will replace some of the sugar in soft drinks through blending with sugar to achieve cost savings.
- Deregulation/privatisation and steps towards trade liberalisation will continue slowly and will bring about major shifts in the world sugar market. It is expected that these shifts will be beneficial to the sugarcane industry at the expense of the high cost sugar beet producers. At the same time it will mean the end of preferential trade arrangements such as the EU-ACP sugar protocol and the US tariff rate quota. However, levelling the playing field is indeed a very slow process and is not expected to happen in the foreseeable future.
- Development of by-products from sugarcane, notably mainstream products such as electricity and ethanol, can have a significant impact on the world sugar market. Large-scale co-generation has the potential to radically change the economic balance of the sugar industry (Dixon and Burbidge, 2000). The promotion of bio-fuel can result in a diversion of sugar to ethanol, as is the case in Brazil.
- A contentious issue is the potential impact of biotechnology on sugar beet and cane breeding. Biotechnology can result in significant increases in yield and alter competitive advantages in the world market. However, this is subject to acceptance of genetically modified food crops by the general public.

Considering all of the above factors, it remains difficult to predict the future of the world sugar market, but it is evident that most individual sugar producing countries have little or no control over that market. Any exposure to the world sugar market is therefore inevitably risky. Renewable energy might just be the vehicle to reduce that risk.

A typical South African sugar factory

The crushing season is eight to nine months, starting in April and finishing in November/December. Approximately 22 million tons of cane are delivered to 15 factories varying in size between 90 and 550 t/h, with most averaging about 300 t/h or 1.5 million tons of cane per annum. At this throughput the boiler steam is just over 160 t/h. This steam is typically at a pressure of 3000 kPa(a) and a temperature of 400°C, and is normally exhausted through steam turbines and turbo-alternators to 200 kPa(a). Total internal power requirements for a raw sugar factory are between 35 and 40 kWh/tc. Exhaust steam is used in multiple effect evaporation and juice heating. Although most factories are operating quintuple evaporation stations, others are still using quadruple evaporation. Pan floors are predominately using vapour-1 steam, and syrup brix is rather low at 65%. Mixed juice is heated in two stages using vapour-2 and vapour-1 steam and, in a diffuser factory, scalding juice heaters are operating on vapour-2 steam.

The need for additional fuel (mostly coal) varies from factory to factory and from time to time. It depends mainly on factory and process design, the steadiness of operation and the fibre content of the cane. Most sugar factories are designed to burn bagasse inefficiently so as to avoid the need for a costly bagasse disposal system. Others are fitted with a back-end refinery (Malelane, Pongola, Umfolozi, Gledhow and Noodsberg), or are exporting bagasse (Malelane, Felixton, Gledhow, Maidstone and Sezela) and burning significant amounts of coal. At present only Komati, Felixton and Maidstone are doing a little co-generation. The selling price varies significantly and ranges from 3 to 49 c/kWh depending on the time of year, the time of day and the electricity buyer (Table 2).

The sugar industry has standardised on the three boiling scheme with partial remelt to produce sugar with a very high pol (VHP) of 99.3% and 1500 ICUMSA colour units. Only A-sugar is bagged, and part of the B-sugar is used to make a B-magma as footing for the A-pan. The remainder of the B-sugar together with the C-sugar is remelted and mixed with syrup to form the feed to the A-pan. Final or C-molasses typically has a dry solids content of 80% at a true purity of 40%. This molasses is normally sold for about R180/ton to third parties for the production of potable alcohol and animal feed. The cane to sugar ratio is about 8.6. Average sugar price is around R2100/ton, with the export and local price being R1300 and R2900/t respectively.

Table 2. The selling price of electricity in South Africa.

Electricity buyer	Peak (c/kWh)	Standard (c/kWh)	Off-peak (c/kWh)
Durban Metro (Jun, Jul, Aug)	49.43	15.14	7.71
Durban Metro (Sep-May)	14.26	10.02	4.38
ESKOM	8.46	7.56	3.28

Co-generation

Electricity generating capacity in South Africa is currently approximately 37 000 MW. In 2001 the electricity demand amounted to 179 000 GWh, with an annual growth of 2.8% (Anon, 2003a). In the South African sugar industry the total installed power is about 240 MW (Wienese, 2002), which is used mainly to meet factory requirements, with little electricity being exported. However, sugar factories have the potential to increase this export of power by means of reducing process steam, increasing boiler and turbine efficiencies, increasing the fuel supply with tops and trash, and combined cycle technology (Figure 1). Most of the following information on co-generation is based on the work of Wienese (2003).

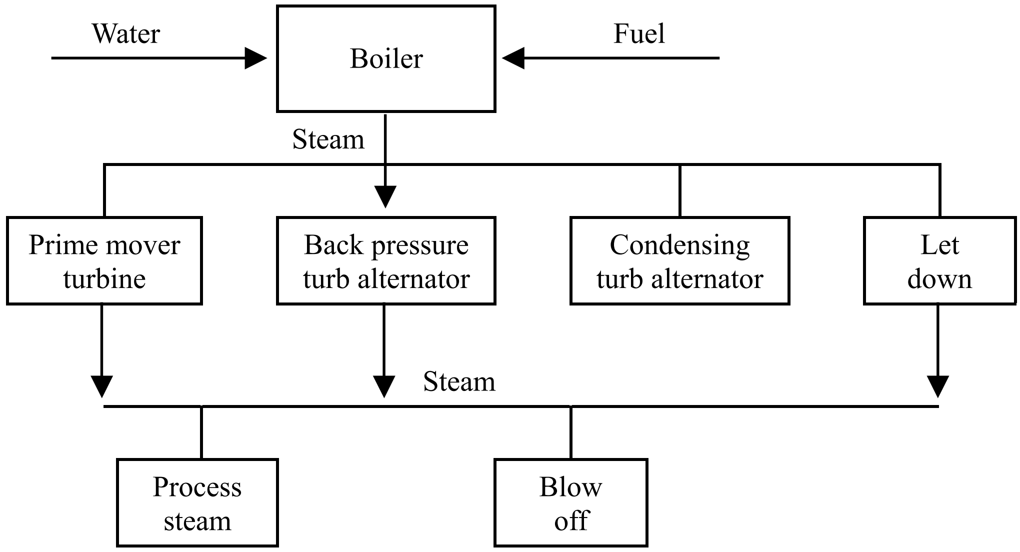

Figure 1. Typical steam and power generation for a sugar factory.

Reducing process steam consumption

In an average raw sugar factory, the process steam as a percentage on cane is between 55 and 60%. This is excessive by international standards (Australia is between 45 and 52% (Broadfoot, 2001)) and is mainly due to high imbibition rates and a costly boiling scheme. In a co-generation environment this is unacceptable and a figure of between 40 and 45% is sought. Several recent publications deal with measures to reduce process steam for the purpose of co-generation (Wright, 2000; Kong Win Chang and Wong Sak Hoi, 2001; Broadfoot, 2001; Moller *et al.*, 2003).

These measures include:

- Reduce imbibition
- Increase number of evaporator effects
- Change to lower bleeding
- Operate at optimum syrup brix
- Use continuous pans
- Efficient boiling scheme
- Steady operation
- Reduce pan movement water
- Optimise condensate flashing.

A reduction in process steam from 60 to 45% on cane results in a total power generating capacity of about 69 kWh/tc.

Increased steam and power generating efficiencies

One way to increase potential export power even further is to increase steam and power generation efficiencies. This can be achieved by the replacement of existing boilers (3000 kPa(a)/400°C) with high pressure boilers (8000 kPa(a)/480°C), installing a mixture of highly efficient back pressure and condensing turbo-alternators and replacing steam turbine prime movers with electric and/or hydraulic drives. The power plant does not necessarily need to be under the control of the sugar factory. In Mauritius, Reunion and Australia some generating facilities are operated by a power utility to ensure reliability of the energy supply (Mason, 2001). A sugar factory with a highly efficient power station combined with low process steam should be in a position to generate about 133 kWh/tc.

Increased fuel supply with tops and trash

During the harvesting process, trash and tops are removed and only the stalks are delivered to the factories. The trash is usually removed by burning (80%) and the tops are cut by hand and left in the field. Leaving trash and tops in the field is seen by many agronomists as beneficial because of its nutritional value, contribution to weed control, protection against erosion and retention of moisture in the soil. However, the trash and tops combined is very similar to bagasse in both quality and quantity and has the potential of doubling the amount of fuel that can be produced from sugarcane (de Beer *et al*., 1989). Ways of recovering trash and tops and separating them from the stalk are being explored. In Australia the separation of trash and tops at the factory is being investigated (Schembri *et al.*, 2002). In Brazil tests are being conducted with the baling of trash and tops in the field (Hassuani, 2001). Burning bagasse and tops and trash increases the power that can be generated to 302 kWh/tc.

Biomass integrated gasification/combined cycle (BIG/CC)

Without trash and tops, the conventional steam power plant is incapable of increasing electricity-generating rates much beyond 130 kWh/tc and new technologies are being explored. The most promising is the Biomass Integrated Gasification/Combined Cycle (BIG/CC), which has been the subject of many publications (Hobson *et al.*, 2003; Morris *et al.*, 2002; Turn *et al.*, 2002; Linero *et al.*, 2001; Joyce *et al.*, 1999; Wienese, 1999). It is based on the gasification of bagasse to form a combustible gas that can be used in a gas cycle on top of the steam cycle currently employed. To make full use of Combined Cycle technology the process steam on cane has to be brought below 40%. The projected yield of this Combined Cycle is in excess of 200 kWh/tc. When trash and tops were included this could be as high as 460 kWh/tc. Combined Cycle technology is currently in a development stage and lacks detailed financial and technical information. However, it is expected that in the long term this technology will be competitively priced and can make a significant contribution to co-generation (Dixon and Burbidge, 2000).

Cost and revenue of co-generation

An accurate estimate of the potential power generation capacity of the sugar industry and the associated cost requires a detailed study of each of the 15 sugar factories. This is a complicated and lengthy exercise. Due to time constraints the present work was limited to an average raw sugar factory of 300 tons of cane per hour or 1.5 million tons of cane per annum. For the four scenarios considered, the power and energy available for export is summarised in Table 3. It is assumed that the internal power required to operate a raw sugar factory is 40 kWh/tc.

Table 3. Export power and energy for different scenarios for a 300 tch raw sugar factory.

Scenario	Power (MW)	Energy (kWh/tc)	Energy (GWh)
Reduced process steam demand	8.60	28.69	43.00
Improved steam and power generation	27.88	92.94	139.40
Increased fuel supply with tops and trash	78.55	261.83	392.75
Combined Cycle technology	>120.00	>400.00	>600.00

The capital, operating and maintenance cost and the cost of energy for the different scenarios are given in Table 4. The operating and maintenance cost is taken as 3% of the capital cost minus the cost of obsolete equipment. Added to the operating and maintenance cost is the cost of loss of sucrose due to reduced imbibition. The annualisation of the capital cost is based on a life span of

34 years and a discount rate of 10% (annuity rate of 10.41%). No allowance is made for possible carbon credits, which account for 3 c/kWh (US$3.5 per ton of CO_2).

Table 4. Capital, operation and maintenance, and cost of energy for different scenarios for a 300 tch raw sugar factory.

Scenarios	Capital cost (R`10^6)	O&M cost[1] (R`10^6/y)	Energy cost (c/kWh)
Reduced process steam demand	84	3.42	28.23
Improved steam and power generation	380	8.20	34.25
Increased fuel supply with tops and trash	831	43.94	33.21
Combined Cycle technology	~	~	>40.00

[1]Operating and maintenance cost includes the cost of loss of sugar

In 2003 ESKOM's average cost of electricity, which is the marginal cost without capacity constraints, was between 8 and 10 c/kWh (Anon, 2003a). The long run marginal cost, which takes into consideration the cost of additional capacity, is substantially higher. A new coal fired 3558 MW power station with an annual production of 22 000 GWh costs about R28 464 million (R8000/kW). Fuel and other consumables are estimated at 5.4 c/kW and operating and maintenance costs are R854 million per annum (3% of capital). The methodology used for costing renewable energy gives a cost for electricity of 18 c/kWh but can be as high as 25 c/kWh depending on gas cleaning equipment. However, this does not take into consideration the environmental cost associated with coal-fired power stations. This cost is difficult to quantify but is given a value of 5 c/kWh (Anon, 2003a). The real cost of electricity is therefore between 23 and 30 c/kWh, which is the benchmark for the cost of electricity from renewable energy.

Presently maximum co-generation that can be achieved practically is through low process steam usage and efficient steam and power generation. At over 34 c/kWh, this scenario does not compare well with a coal fired power station. However, for a newly built sugar factory the capital cost can be reduced by about R150 million through avoiding the capital cost of conventional operation. This results in about 23 c/kWh which is in line with the real cost of electricity from a coal fired power station. Burning coal during the off crop could reduce this figure even further. An arbitrary selling price of 40 c/kWh provides an average raw sugar factory with additional revenue from co-generation of roughly R55 million per annum. To put this into perspective, for the same factory, the proceeds from sugar, based on an average price of R2100 per ton, is about R366 million per annum.

Bio-ethanol

Ethanol for fuel purposes has attracted periodic attention in the South African sugar industry. The last period of interest was stimulated by the high petrol prices in the 1970s and it resulted in a number of publications (Thompson, 1979; Ravnö, 1979; Buchanan, 1979; Purchase, 1983). With the stabilisation of fuel prices, interest in ethanol steadily declined, but not before the industry had almost gone ahead with a large distillery at Felixton. Work had been done on syrup weighing and factory balances at Felixton to determine appropriate prices for syrup diverted to ethanol. Visits had been made to Brazil, and good working relations had been established with ethanol experts at COPERSUCAR. A Government subsidy for ethanol had been agreed, but in the final analysis the investment in fuel ethanol production was not attractive and the scheme was abandoned in 1990. By that time the Sugar Milling Research Institute had participated in a

National Research Programme funded by Government and aimed at converting bagasse to ethanol. Considerable knowledge and expertise for such a process had accumulated (Paterson-Jones, 1989) but further development was suspended.

What has changed?

The following factors make it prudent to reconsider fuel ethanol as a source of revenue for the South African industry, and as a means of reducing pollution and creating employment in the country:

- The export price of sugar has declined in real terms (Figure 2) and it is likely that the oversupply position will continue in the long-term (Baron, 2002).

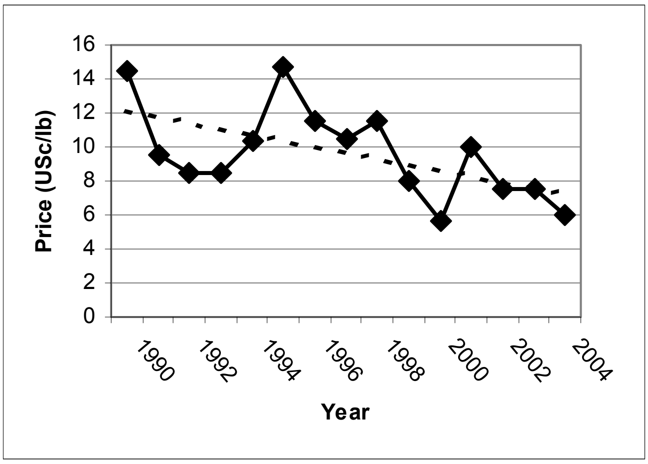

Figure 2. New York commodities exchange no. 11 - sugar price trend.

- The price of petrol has increased (Figure 3).

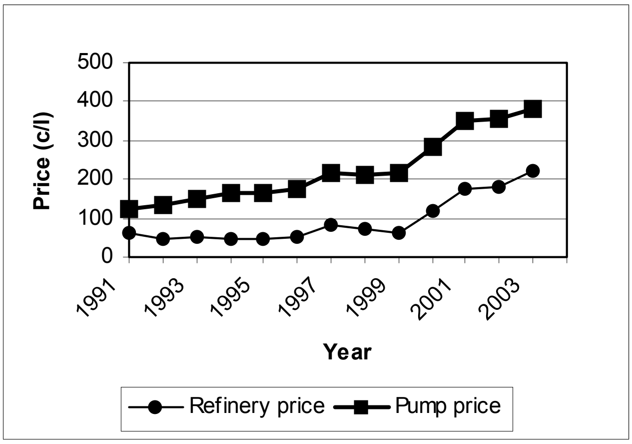

Figure 3. South African fuel price trend (93 octane at the coast).

- An analysis of the Brazilian situation (Berg, 2003) suggests that since early 2003 the revenue per ton of recoverable sugar has been higher if the sugar is converted to ethanol than if it is exported. This is an unusual situation but it has been sustained for a relatively long period.
- Flexi-fuel engines capable of adapting automatically to fuel blends containing 0 to 85% ethanol or to hydrous ethanol (96% ethanol, 4% water) have been developed recently and have been well received by the market, thus eliminating customer resistance to ethanol engines (which could only run on hydrous ethanol and were therefore stranded when Brazil suffered a shortage of ethanol).

- There is concern over the use of methyl tertiary butyl ether (MTBE) as a replacement for lead in petrol (it pollutes air and ground waters) and some countries have already legislated phased withdrawal of MTBE. Ethanol is a potential replacement for MTBE, either directly or as a component of ethyl tertiary butyl ether (ETBE), which is non-polluting (Berg, 2003).
- Progress in technology has reduced the cost of ethanol production and has eliminated concerns about sustainable effluent disposal and engine wear.
- Interest in bio-diesel has re-emerged. Ethanol is needed to react with and blend with bio-diesel to ensure trouble-free operation.

Perspectives

A recent Government study has assumed that ethanol could never be made economically from sugar as such, but only from molasses. This has led to a perception that only a negligible amount of fuel alcohol could be made by the sugar industry (Mtwa, 2004). If it is assumed that some sugar could be diverted to ethanol and that some fermentables could be derived from hydrolysis of bagasse then the perspective changes to that summarised in Table 5.

Table 5. Perspectives on potential ethanol production.

Scenarios	Substrate (tons)	Fermentables (tons)	Ethanol (tons)
Surplus molasses	200 000	90 000	39 600
Export sugar	1 300 000	1 290 900	567 996
Bagasse surplus	1 000 000	577 500	231 000
Some tops and trash	100 000	57 750	23 100
Additional sugar ex expansion	260 000	258 180	113 599

Scenarios	Cumulative Ethanol		
	tons	% on petrol	% on petrol and diesel
Surplus molasses	39 600	0.4	0.3
+ export sugar	607 596	6.8	4.1
+ bagasse surplus	838 596	9.3	5.6
+ some tops and trash	861 696	9.6	5.7
+ add sugar ex expansion	975 295	10.8	6.5

Calculations are based on the following assumptions:

Ethanol yield on sugar	0.44
Sugar export tonnage	1 300 000
Molasses fermentables fraction	0.45
Bagasse surplus (tons dry basis)	1 000 000
Ethanol yield on bagasse	0.23
Tops and trash supplement (on bagasse)	0.10
Tons additional sugar ex expansion	260 000
Petrol consumption (t)	9 000 000
Diesel consumption (t)	6 000 000

It is evident that molasses has a negligible role in fuel ethanol production. Significant production could come from diversion of export sugar and/or expansion of sugar production. The use of bagasse for ethanol production may be economically possible in the future but burning of the bagasse for co-generation is likely to be a better option. An important conclusion from Table 5 is that the market for fuel ethanol is huge and could easily absorb all of the export sugar and molasses, this contributing only about 4% to the country's liquid fuel pool.

The basic pricing benchmark

The petrol price ex refinery is a basic benchmark in considering fuel ethanol economics. This ex refinery price is generally referred to as the in bond landed cost (IBLC) and is shown in Figure 4.

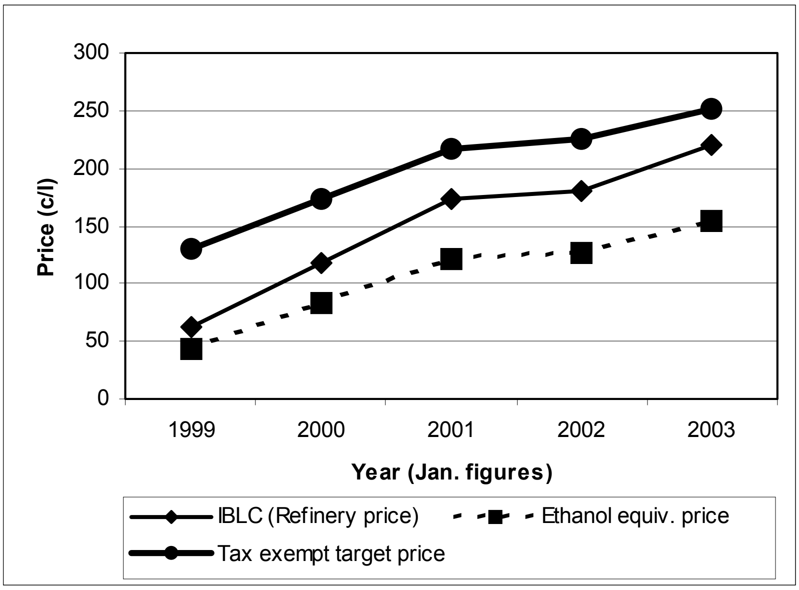

Figure 4. Refinery price of petrol and associated target prices for ethanol.

For energy equivalence, ethanol must sell at a 30% discount to this price, hence the 'ethanol equivalence price' line in Figure 4.

Table 6. Component costs of retail petrol price (c/l).

Component	1999	2000	2001	2002	2003
IBLC price	62.00	118.00	174.00	181.00	220.00
Tax	86.60	90.60	95.60	98.00	98.00
Customs and excise	4.00	4.00	4.00	4.00	4.00
Equalisation fund	8.00	0.00	0.00	0.00	2.00
Road accident fund	14.50	14.50	14.50	16.50	18.54
Transport (to depot)	11.30	11.30	11.30	11.40	11.40
Wholesale margin	17.06	17.56	18.79	24.31	28.30
Retail margin	22.70	24.50	26.50	30.00	32.60
Slate levy	0.00	0.00	8.00	0.00	1.00
Delivery	5.10	5.10	5.10	5.10	5.10
Final pump price (c/L)	231.26	285.56	357.79	370.31	420.94

Source: Department of Minerals and Energy www.dme.gov.za 15 May 2004

The IBLC price is only a portion of the final pump price. The difference is made up as indicated in Table 6. From Table 6 it can be seen that most of the add-on costs are unavoidable but, if fuel ethanol was tax exempt, then additional costs could be incurred in producing it. The 'target cost' line in Figure 4 is the equivalence price plus the tax shown in Table 6. It represents the price at which ethanol needs to be produced if it is tax exempt, but gives equivalent fuel value at the pump.

Substrate costs

The major cost in making fermentation alcohol is the cost of fermentable substrate. The least costly substrate is final molasses, but molasses will not be considered because there is negligible surplus in South Africa. To produce significant quantities of fuel ethanol, it will be necessary to divert export sugar to ethanol. The export price is therefore critical. This is determined largely by the New York No. 11 spot price and the R/US$ exchange rate.

Table 7 shows the price of substrate per litre of ethanol for various scenarios, including various levels of cost savings due to making ethanol instead of export sugar. For example, if the export price of sugar is 7 c/lb, the exchange rate 6 R/$ and the cost saving 15%, then the price of substrate is 134 c/L ethanol. The target (maximum) ethanol price for 2003 was 252 c/L (Figure 4). This means that up to 118 c/L could be spent in manufacturing ethanol from the substrate. Keating *et al.* (2002) estimated operating costs in Australia to be A$0.15/L (excluding capital), with capital costs being A$50 million for a 50 ML/annum plant. Based on these estimates, the production cost (excluding substrate) in South Africa would be about R0.80/L. The shaded figures in Table 7 indicate circumstances where ethanol production might be viable for a target price of 252 c/L, if the manufacturing cost is R0.80/L.

Table 7. Sugar price and cost saving scenarios conducive to fuel ethanol production.

NY No. 11 spot price (US c/lb)	Pol awards & premiums (+4.2%)	Exchange rate (R/$)	SA price (R/t)	Substrate price (c/L EtOH) @ cost savings of (%):				
				0	10	15	20	30
5	0.225	6	691	112	101	95	90	79
		8	921	150	135	127	120	105
		10	1151	187	168	159	150	131
7	0.315	6	967	157	141	134	126	110
		8	1289	209	189	178	168	147
		10	1611	262	236	223	209	183
9	0.405	6	1243	202	182	172	162	141
		8	1657	269	242	229	215	189
		10	2072	337	303	286	269	236
11	0.495	6	1519	247	222	210	197	173
		8	2026	329	296	280	263	230
		10	2532	411	370	350	329	288
13	0.585	6	1795	292	263	248	233	204
		8	2394	389	350	331	311	272
		10	2992	486	438	413	389	340

It must be noted that some of the shaded areas represent circumstances in which sugar would not be available because producer revenue would be below the costs of production. As a rule of thumb the figures indicate that, if the export revenue falls below R1000/t and full fuel tax exemption is granted, then ethanol might be a better option than sugar. If 'savings' of 15% can be achieved through intercepting the fermentables at the juice stage, then the ethanol option would be viable up to a sugar export price of about R1200/t.

The 'savings' envisaged include:

- Not making molasses but using the fermentables previously destined to be sold at a low price as molasses. This represents a 4-5% reduction in the average cost of fermentables.
- Not making crystal sugar and therefore saving costs of evaporation, crystallisation and centrifugation. These savings are limited to about 11% because about 66% of the cost of sugar is incurred prior to the factory and about 66% of the remaining cost is incurred in getting the juice out of the cane.
- Reduced transport costs due to no molasses production and the fact that ethanol would be approximately 44% of the mass of the sugar which would otherwise be made.

An additional cost would be the facilities required for blending the ethanol with petrol.

Summary and conclusions

All over the world, renewable energy is difficult to justify on purely economical grounds and requires Government support in the medium term. Justifications for that support are non-economic issues such as protection of the environment, employment creation and security of energy. This presents an ideal opportunity for the sugar industry to diversify and to reduce its exposure to a declining world sugar economy. In this context there is a growing interest in both co-generation and bio-fuels.

Co-generation

Restructuring of the electricity supply chain, together with a projected shortfall in generating capacity by ESKOM, opens the way for independent power generators to enter into the electricity market. The sugar industry has the capacity to generate excess electricity over and above its own requirements, for export to the grid. The difference between the cost of co-generation and ESKOM's electricity price, based on marginal cost, has prevented the industry from doing so. However, when considering the real cost of electricity, including environmental cost, i.e. externalities, this difference becomes much smaller. It is believed that supporting power generation from bagasse is one of the most cost effective ways for the Government to meet its target of 10 000 GWh of renewable energy.

Bio-fuels

The trend of declining sugar prices accompanied by increasing petrol prices means that the economic viability of fuel alcohol production from export sugar is improving. Some form of Government support is, however, essential if fuel ethanol is to become viable in the medium term. Exemption from fuel tax would make ethanol production attractive only when export sugar prices are at extremely low levels. If ethanol production is deemed to be in the national interest, then a holistic approach involving oil companies, the automobile industry, Government and the sugar industry needs to be initiated. Such an approach has been taken by a number of countries in the past two to three years, and has led to a surge in the production of fuel ethanol and the opening of an ethanol trading exchange in New York.

A combination of direct white sugar, co-generation and fuel ethanol provides true diversification and gives the flexibility to switch between sugar, energy and ethanol production according to relative returns. Such an approach requires a radical transformation of the sugar industry along the lines detailed by Avram and Stark (2004). Because of present capital investment, this transformation is going to be a lengthy and costly process, which needs to be planned well in advance.

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