



**Alternative Energy Brief**  
**September 2007**

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Welcome to the September 2007 Guinness Atkinson Alternative Energy Brief.

In this issue:

- Fund Performance
- Portfolio Breakdown
- Stock Performance
- Trading
- Brazilian Ethanol Analysis

In this issue we further discuss our views on the August market downturn on the alternative energy sector.

## Fund performance

The Guinness Atkinson Alternative Energy Fund was down 5.07% in August which takes us to up 23.98% for the year to date (YTD) 2007. August continued as July ended with sharp falls across all sectors. Towards the end of the month, we saw a decent swing back as recognition that the alternative energy story has drivers that are not significantly affected by the recent subprime issues.

Oil has remained high over the month and demand indicators remain positive. There remains a strong political will behind the sector.

### Total Returns as of 8/31/07

Total returns	August 07	YTD 07	1 Year	From Inception
Guinness Atkinson Alternative Energy Fund (03/31/06)	-5.07%	23.98%	26.85%	9.51%
WilderHill New Energy Global Innovation Index	-4.29%	31.08%	45.38%	27.18%
WilderHill Clean Energy Index	-1.51%	23.16%	16.51%	-0.44%

Gross Expense Ratio 2.60%

Net Expense Ratio\* 1.98%

### Total Returns as of 9/30/07

Total returns	Sep 07	YTD 07	1 Year	From inception
Guinness Atkinson Alternative Energy Fund (03/31/06)	9.49%	35.75%	50.43%	15.75%
WilderHill New Energy Global Innovation Index	8.91%	42.77%	60.83%	32.87%
WilderHill Clean Energy Index	7.32%	32.18%	36.63%	4.38%

Gross Expense Ratio 2.60%

Net Expense Ratio\* 1.98%

\* The expense ratio shown is from the most recent prospectus (April 30, 2007). The Fund has an expense cap in place and the advisor is contractually obligated to cap the total expenses at least through June 30, 2008. The Advisor has guaranteed total fund operating expenses (as a percentage of net assets) will not exceed 1.98% through June 30, 2008 or until such a later date as the Advisor determines.

All return figures represent average annualized returns except for periods of one year or less which are actual returns.

**Performance data quoted represents past performance; past performance does not guarantee future results. The investment return and principal value of an investment will fluctuate so that an investor's shares, when redeemed, may be worth more or less than their original cost. Current performance of the fund may be lower or higher than the performance quoted. Performance data current to the most recent month end may be obtained by visiting [www.gafunds.com](http://www.gafunds.com) or calling 800-915-6566.**

**The funds impose a redemption fee of 2% on shares held less than 30 days. Performance data does not reflect the redemption fee. If reflected, total returns would be reduced.**

## Sector and geographic breakdown

Sector	% of Assets	Region	% of Assets
Solar	35.77%	Europe	50.48%
Wind	16.93%	North America	23.52%
Hydro	15.97%	Asia	12.02%
Geothermal	8.83%	Australia/NZ	6.79%
Biofuel	7.17%	Latin America	6.01%
Fuelcell	6.28%		
Hybrid	2.90%		
Other	2.38%		
Efficiency	1.91%		
Storage	0.41%		

Our current thinking leads us to believe that some of the more favourable areas for investment are in Solar and Wind as companies in this area have already been profitable and have experienced strong demand-driven growth. We think that Hydroelectric and Geothermal are potentially attractive investment areas owing to their operating leverage. For Biofuels, we think that they will play their part over the longer term, but may not necessarily be appropriate for long term investing. Our belief is that feedstock prices (of all types) may rise as the incremental demand on feedstocks for fuel is “game-changing” for agriculture. We are therefore most interested now in biofuel investments that are vertically integrated (i.e. they produce their own feedstock).

The Fund continues to have a European bias, with 50.48% of the Fund reflecting the relatively higher maturity of the European solar and wind industries. We now have 24.82% invested across Asia, Australia/NZ and Latin America, in some very interesting opportunities that we believe are missed by many looking at the alternative energy industry. This gives us exposure to emerging markets growth and reflects the global nature of this industry – many of the “solutions” are specific to their relevant geographies, such as Geothermal in the Philippines and Hydro in more mountainous areas.

## Liquidity analysis

Mkt Cap \$m	Positions	% of Assets	Position size	Positions	% of Assets
>1000	24	58.57%	Full	12	38.53%
500-1000	7	13.11%	Half	31	53.47%
250-500	5	6.42%	Research	23	6.80%
100-250	13	13.06%			
50-100	8	4.97%			
<50	10	2.67%			

The liquidity of the portfolio remains good. Roughly half (58.57%) of the portfolio is in stocks with a market capitalisation of over \$1 billion and only 2.67% of the portfolio is

invested in stocks with a market capitalisation below \$50 million. We are endeavouring to maintain a balance between holding larger capitalisation more liquid stocks and positions in smaller capitalisation less liquid stocks where the value and growth opportunity might be greater. We have segmented the portfolio into three types of holding: full, half and research. We currently hold 12 full units and 32 half units, with a further 23 research positions. This also enables us to benefit from a strict rebalancing discipline. Over the month we have reclassified a number of positions as research positions where our appetite for additional exposure was reduced as a result of the position size. We remain enthusiastic about these stocks and will opportunistically increase our positions rather than trading with flows.

### Stock performance

Top 5	Size	Aug	Bottom 5	Size	Aug
Echelon Corp	Half	41.87%	China Sunergy	Half	-52.65%
Solon AG	Full	31.63%	Westport Innovations	Half	-35.32%
Fuelcell Energy	Half	30.71%	Babcock & Brown Environmental	Research	-31.82%
WFI Industries	Half	11.08%	CMR Fuel Cells	Research	-30.29%
Fuel Systems Solutions	Full	8.18%	VRB Power Systems	Research	-24.21%

Amidst the difficult markets of August, we had some highlights. Echelon picked up a Russian contract which helped it continue its strong performance – it has been our most favoured efficiency stock. We had increased our holding in Solon from a half to a full unit following a visit to the company and were pleased to see the stock up 31.63% in August as industry growth forecasts were raised. Fuelcell Energy is one of only 3 non research fuelcell holdings in the Fund and benefited from announcing new orders in August. WFI Industries are a manufacturer and installer of ground source heat pumps which dramatically improve energy efficiency. They have performed very well from when we first bought into the name. Fuel System Solutions has been relatively volatile and the 8.18% August performance must be seen in the context of that volatility.

China Sunergy was a great disappointment to us. We had bought the stock at IPO in May and were surprised when they announced that the CFO was leaving and that the company would not reach profitability until later than expected. Westport was hit hard as a less liquid stock that has performed well YTD (up 76% to end August). We believe that Westport is potentially placed for growth in the west coast CNG market. The remaining three poor performers were research positions hurt by the market conditions.

### Trading

During the late month turmoil we bought a position in Sunpower, the manufacturer of the most efficient actively marketed PV Cells. We also switched from Ceres Power into ITM, as we believe ITM offers better value now.

## **Brazilian ethanol analysis**

Please find attached as an appendix to this month's brief a report we have put together on the Brazilian ethanol market. We do not currently own any Brazilian ethanol refining companies, although we do own a biodiesel refining company - Brazil Ecodiesel. We have concerns about investing in Brazilian ethanol refiners because of the weak state of global sugar markets as a result of increased Indian sugarcane capacity. To date Brazilian ethanol prices have been driven by these sugar prices, as ethanol refining capacity exceeds the domestic demand. Domestically the main drivers of ethanol consumption growth are increased Flex Fuel Vehicle sales (over 86% of all new vehicle sales) and the discount that ethanol trades at to gasoline prices. Eventually we would expect to see a stronger correlation with gasoline prices and we will look to find an appropriate entry point into Brazilian ethanol stocks. Additionally Brazilian refiners are able to lock in local sugarcane at fixed prices because it is not economical to transport the sugarcane long distances. This mitigates to a certain extent the potential for market related increases in feedstock prices.

One of the reasons we think it is important to understand the Brazilian market is that they were the first country to embrace ethanol and have gone through a number of the stages that are needed for widespread adoption of biofuels. We do not believe that biofuels will solve the world energy problems, but we do believe that they will play a part in reducing tight fossil fuel supply issues. In our opinion, Brazil is one of the best placed countries to export on a large scale. As well as being one of the lowest cost producers, Brazil has significant non rainforest arable land that is not used at the moment and could be turned to sugarcane production. We hope that Brazil will lead the way to a global 10% renewable fuel mandate and beyond and in the process develop a more robust economy. We hope you find the report of interest.

Thank you for your continuing support.

Tim Guinness  
Edward Guinness  
Matthew Page  
*September 2007*

Commentary for our views on global energy and Asia markets is available on our website. Please [click here](#) to view.

Total returns reflect a fee waiver in effect and in the absence of this waiver, the total returns would be lower.

This information is authorized for use when preceded or accompanied by a prospectus for the Guinness Atkinson Global Energy Fund. The prospectus contains more complete information, including investment objectives, risks, charges and expenses related to an ongoing investment in the Fund. Please read the prospectus carefully before investing.

*The Fund invests in foreign securities which will involve greater volatility and political, economic and currency risks and difference in accounting methods. The Fund is non-diversified meaning its assets may be concentrated in fewer individual holdings than diversified funds. Therefore, the Fund is more exposed to individual stock volatility than diversified funds. The Fund also invests in smaller companies, which will involve additional risks such as limited liquidity and greater volatility.*

Fund holdings and/or sector allocations are subject to change at any time and are not recommendations to buy or sell any security.

The WilderHill New Energy Global Innovation Index (NEX) is a modified dollar weighted index of publicly traded companies which are active in renewable and low-carbon energy, and which stand to benefit from responses to climate change and energy security concerns.

The WilderHill Clean Energy Index (ECO) is a modified equal dollar weighted index comprised of publicly traded companies whose business's stand to benefit substantially from societal transition toward the use of cleaner energy and conservation.

One cannot invest directly in an index.

<b>Top Ten Holdings as of 8/31/07</b>	<b>% of Assets</b>
Solon AG Fuer Solartechnik	3.87%
Vestas Wind Systems A/S	3.43%
PNOC Energy Development Corp	3.42%
Conergy AG	3.31%
Q-Cells AG	3.29%
Gamesa Corp Tecnologica SA	3.28%
Solarworld AG	3.23%
Renewable Energy Corp AS	3.21%
Ormat Technologies Inc	3.15%
Verbund AG	3.14%

Distributed by Quasar Distributors, LLC (10/07).

## APPENDIX

### Brazilian Ethanol Report

#### 1. Background

In 1975 the Brazilian government initiated the Pró-Álcool Program, the world's largest renewable energy program, in response to the 1973 oil crisis. This was a nation-wide, government-financed program intended to improve energy security by phasing out all automobile fuels derived from fossil fuels in favour of sugarcane ethanol<sup>1</sup> (ethyl alcohol). The program included major incentives for increasing the installed capacity for ethanol production: sugar plantations, mills, distilleries and storage infrastructure. It also mandated the blending of anhydrous (absolute) alcohol with gasoline in specific and increasing quantities. The result is a gasoline-ethanol mix known as 'gasohol', which is the only gasoline-equivalent sold in Brazil.

Anhydrous ethanol is maximum strength, dehydrated ethanol<sup>2</sup> that requires removal of the 4 to 7% water content of hydrous (hydrated) ethanol<sup>3</sup>. Dehydrated ethanol is necessary when blending with gasoline in standard vehicles in order to prevent the engine stalling. All standard vehicles can operate on between 10 to 15% anhydrous ethanol content with no impact on performance, although the official industry level is 5 to 10% ethanol (for liability reasons). Under the government mandate however, all Brazilian cars have been modified so they can operate on gasohol, which must contain between 20 to 25% anhydrous ethanol. The current government requirement is 25% ethanol content<sup>4</sup> but this varies according to product availability, relative gasoline prices and other factors<sup>5</sup>.

Brazilian Flex Fuel Vehicles (FFVs), introduced in 2001 in response to high petroleum prices, can operate on any blend of (hydrous and/or anhydrous) ethanol and gasoline, or 100% of either gasohol, gasoline or hydrous ethanol<sup>6</sup>. In practice though, due to product availability, FFVs in Brazil tend to operate on either 100% gasohol, 100% hydrous ethanol or a blend of the two. Alcohol-only vehicles, first introduced in 1979 and very popular in Brazil in the 1980s, operate on 100% hydrous ethanol only. This is a less efficient fuel source than either anhydrous ethanol or gasoline and requires a specific engine. Hydrous ethanol accounts for a larger proportion of production (56% in 2006)

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<sup>1</sup> The decision to produce ethanol from fermented sugarcane (above other carbohydrates) was due to the low cost of sugar at the time, and the relative energy efficiency of sugarcane ethanol.

<sup>2</sup> Anhydrous ethanol is minimum 99.7% ethanol (maximum 0.3% water content).

<sup>3</sup> Hydrous ethanol is 93 to 96% ethanol content.

<sup>4</sup> Updated from 23 to 25% in July 2007.

<sup>5</sup> As the Brazilian government controls gasoline prices and the ethanol mandate, ethanol demand is politicized in Brazil.

<sup>6</sup> 100% ethanol is known as E-100. This contrasts with American FFVs which can only operate on a maximum of 85% anhydrous ethanol (E-85).

than anhydrous ethanol, but this is largely due to exponential growth in FFV sales and the high volume of hydrous ethanol exports<sup>7</sup>.

Total ethanol production has risen year on year since 2000, with production of 4,491 million gallons in 2006. Brazil is no longer the world's largest producer however, being surpassed by U.S. production of 4,855 million gallons in 2006. Nonetheless Brazil fully supplies its domestic market and is the world's largest ethanol exporter (shipping over 900 million gallons in 2006) and lowest cost producer<sup>8</sup> due to the relatively low costs of sugarcane<sup>9</sup>, labour and refining. It has aspirations to use its 32 years experience to lead the global ethanol market, and it is working towards producing enough ethanol to supply the entire Brazilian market and substitute 10% of the gasoline consumed worldwide by 2025<sup>10</sup>. This would mean total production of approximately 55 billion gallons of ethanol by 2025<sup>11</sup>, an ambitious<sup>12</sup> but attainable target according to recent studies. Ethanol currently represents only 2.6% of the worldwide gasoline market, but a large number of countries are committed to increasing ethanol consumption<sup>13</sup>.

## **2. The Brazilian Ethanol Market**

### **2.1 Demand**

Domestic ethanol demand is highly dependent on sales of alcohol-only and FFVs, and on gasoline prices. Ethanol forms about 40% of the 8 billion gallons of fuel used to power Brazil's fleet of 22 million light passenger vehicles each year; about 11% of which are FFVs. This is a number that is growing substantially each year as FFVs currently constitute 86.2% of new car sales<sup>14</sup>.

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<sup>7</sup> Hydrous ethanol is exported from Brazil; the majority of this is dehydrated in Caribbean Basin countries in order to maximize tax efficiency.

<sup>8</sup> Currently produce at about \$0.70 per gallon.

<sup>9</sup> The cost of sugarcane production is approximately \$165 per ton in Brazil vs. \$700 per ton in the U.S.

<sup>10</sup> Mario Osavo, *'Brazil aims to dominate world energy market'*, IPS, March 31, 2007.

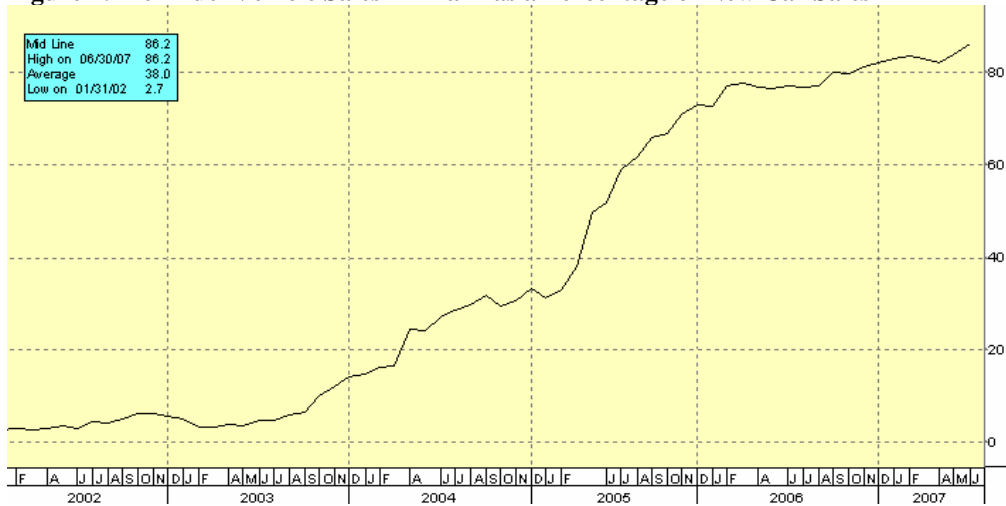
<sup>11</sup> Mario Osavo, *'Brazil aims to dominate world energy market'*, IPS, March 31, 2007.

<sup>12</sup> World production of ethanol in 2006 was only 13.5 billion gallons.

<sup>13</sup> Driven in large part by Kyoto commitments and concerns over political instability in oil producing regions.

<sup>14</sup> The Brazilian Association of Automobile Manufacturers (ANFAVEA), July 11, 2007.

**Figure 1: Flex-Fuel Vehicle Sales in Brazil as a Percentage of New Car Sales**



Source: ANFAVEA, Bloomberg, July 2007

As FFVs give Brazilian consumers the option to select gasohol or hydrous ethanol ‘at the pump’ depending on relative prices, high gasoline prices are driving both FFV sales and hydrous ethanol demand. As pure ethanol has a lower energy content than gasoline (about 30% less energy per unit) ethanol is a better buy only if priced at 70% or less of the price of gasoline. Therefore, in theory, all FFV owners will opt for gasoline if the price of ethanol rises above 70% of the price of gasoline<sup>15</sup>.

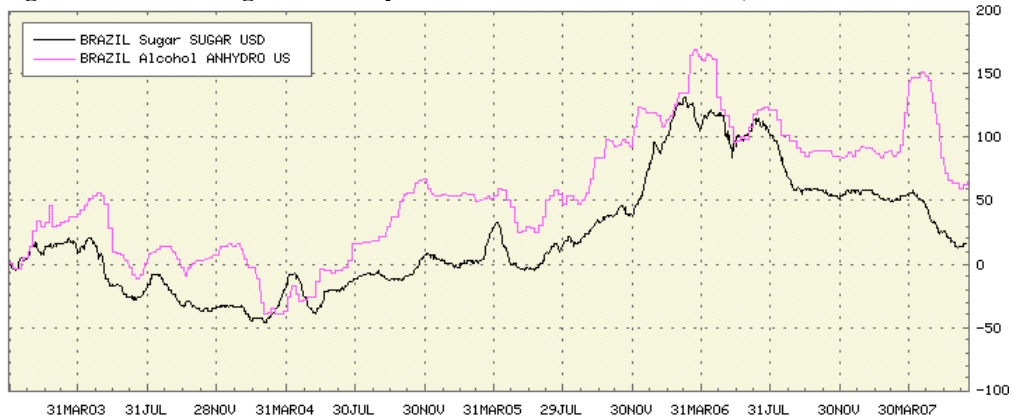
**Figure 2: Relative Brazilian Ethanol (black) and Gasoline (blue) Prices ‘at the pump’**



Source: Bloomberg, July 2007

<sup>15</sup> Ethanol fuel’s retail cost in Brazil was 62% of the price of gasoline (April 2005 – April 2006).

**Figure 3: Relative Sugar and Anhydrous Ethanol Prices in Brazil, 2003-2007**

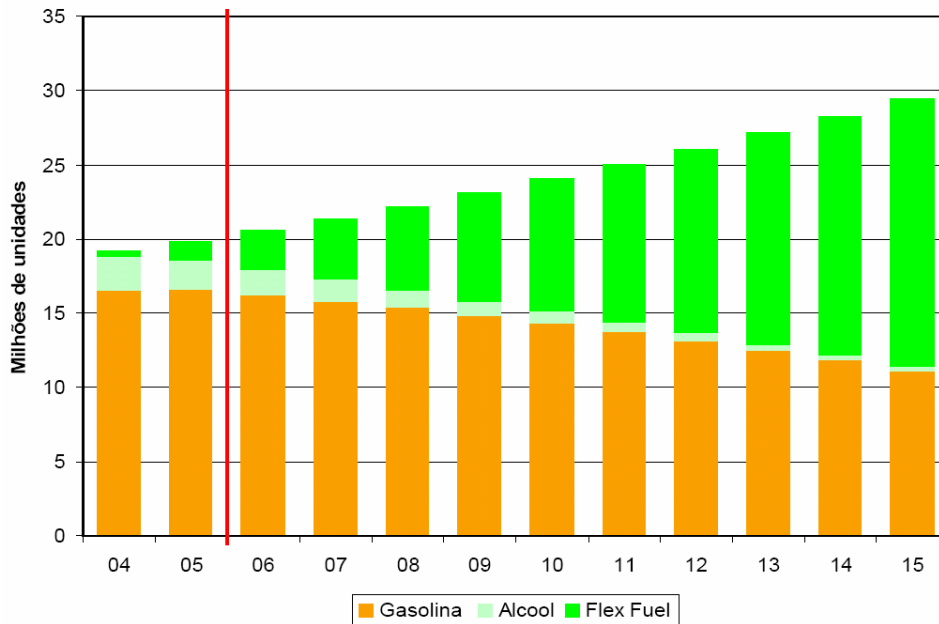


Source: Bloomberg, July 2007

However, as the above charts indicate, to date ethanol prices have been driven by sugar not gasoline prices. This is because the potential supply of ethanol in Brazil currently exceeds the maximum demand. This reduces profit margins in the industry as market saturation forces ethanol producers to sell at a price only marginally above sugar and thus only marginally above cost. However this is a situation that is forecast to change as the ethanol market becomes more established and FFV-driven demand grows.

In contrast to FFVs, sales of alcohol-only vehicles have been in decline since the early 1990s, reflecting the price ratio of petroleum to ethanol and in response to late 1980s ethanol supply shortages. This decline significantly impacted the domestic ethanol market and in 1993 the Brazilian government decided to impose a minimum anhydrous ethanol content of 22% in gasohol in order to prevent a collapse of the entire alcohol production structure. Alcohol-only vehicles now represent only 1% of new car sales, but they have been superseded by the growth in FFV sales. Consumers may remain unconvinced that ethanol will remain cheaper than gasoline but the latter gives drivers the option to choose according to price and performance.

**Figure 4: Forecast of Brazil's Car Fleet by Vehicle Type**



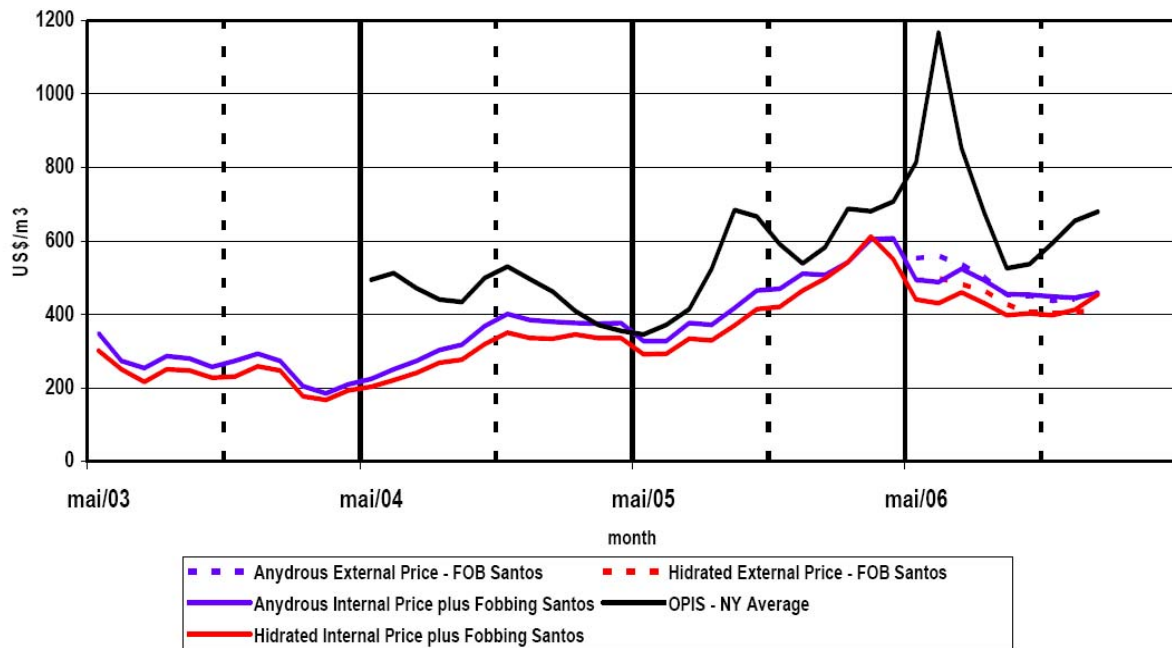
Source: Copersucar Presentation, 2007

The ethanol industry is now well established within Brazil, and it is expected that the ethanol mandate for gasohol will be raised further as the government consolidates the Brazilian biofuel market. Although there are an increasing number of FFVs on the road, they are not being used to their capacity and relatively little ethanol is being consumed outside of Sao Paulo state due to limited infrastructure and thus product availability. The objective is to further secure ethanol in the domestic fuels market by boosting local consumption of ethanol from 320 to 400 million gallons a month. This will help buffer the domestic market against international ethanol price fluctuations.

These ethanol price fluctuations are driven in large part by U.S. policy. For example, the U.S. ban on MTBE as an additive to gasoline in 2006 which led to a sharp spike in global ethanol prices. As direct exports to the U.S. only occur when there is a marked price differential between U.S. and Brazilian prices<sup>16</sup> these fluctuations result in sporadic, direct exports to the U.S. that only last as long as the price difference. This occurred for several month-long periods in both 2005 and 2006 (see graph overleaf).

<sup>16</sup> Because of the U.S. import tariff and ad valorem tax, and costs of transport (see Figure 1).

**Figure 5: Domestic (Brazilian) Prices X US Prices (NY)<sup>17</sup>**



Source: Copersucar Presentation, 2007

## 2.2 Production

Ethanol is a 'commodity business' with a highly variable profit margin, which mostly depends on the prices of other commodities: namely gasoline and sugar cane. As sugar prices decrease, the proportion of ethanol to sugar production (from cane) tends to increase, and vice versa. Second quarter 2007 sugar prices have been depressed<sup>18</sup>, and as a consequence ethanol production has increased both in total and in proportion<sup>19</sup> to sugar production. However, second quarter global ethanol prices have also been depressed this year due to increased global production in response to a spike in ethanol prices in 2006<sup>20</sup>. This spike led to 146 new mill projects<sup>21</sup> being announced as of September 2006, but industry analysts predict only 50 will go ahead as two thirds have been suspended due to lower sugar and ethanol prices<sup>22</sup>. Nonetheless ethanol output for 2007 is likely to reach 4,860 million gallons<sup>23</sup>, an increase of 370 million gallons from 2006.

<sup>17</sup> 1 m<sup>3</sup> = 264.172 gallons.

<sup>18</sup> International sugar prices have fallen to around \$320/tonne (06/2007) from 2006 levels of \$500/tonne. This is due to a worldwide sugar glut, in part due to India's increased sugar production and exports to the Middle East (Dawn Group, June 11, 2007).

<sup>19</sup> Ethanol production is expected to be 53% of ethanol-sugar production in 2007, compared to 51% in 2006 (Kingsman Ethanol Report, May, 22 2007).

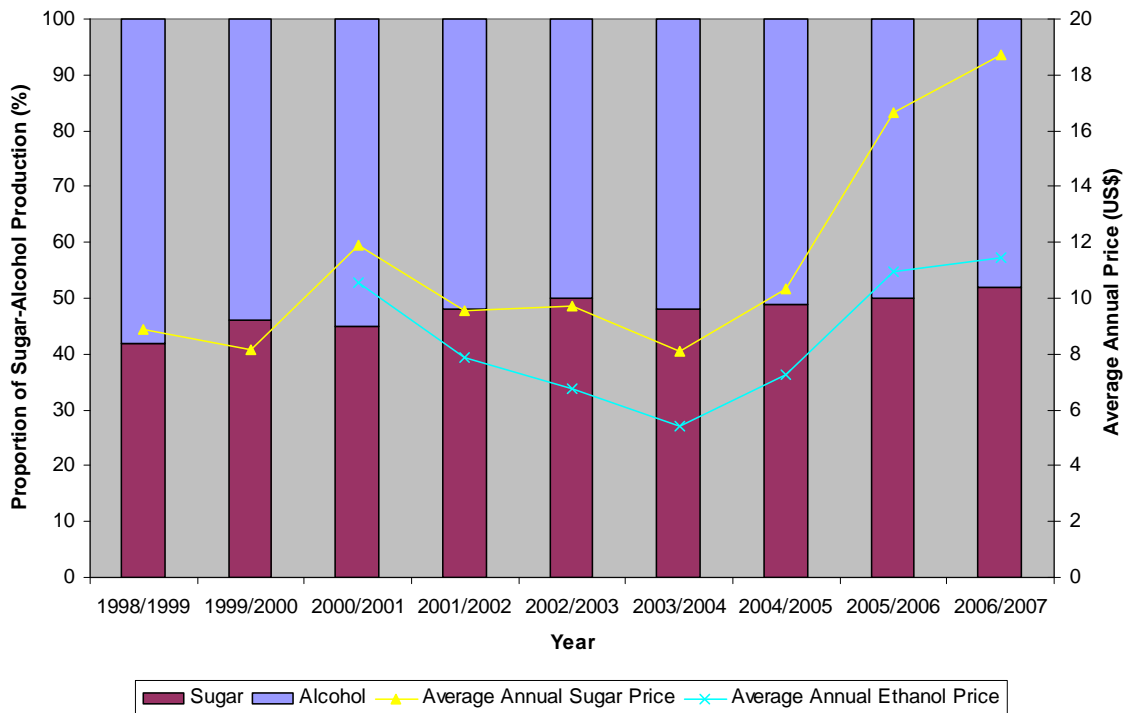
<sup>20</sup> This was due to demand outstripping supply in response to high oil prices and the MTBE ban in the US. The latter resulted in ethanol being purchased as an additive (oxygenate) for gasoline..

<sup>21</sup> Traditionally ethanol refineries were add-ons to sugar refineries. Recently, geographically separate, ethanol-only refineries have been being built in Brazil and a greater number of new refineries are ethanol than sugar.

<sup>22</sup> Job Consultoria as cited in Kingsman Ethanol News Summary, July 10, 2007.

<sup>23</sup> Domestic consumption of 3,960 million gallons, and exports of 900 million gallons.

**Figure 6: Proportion of Sugar-Alcohol Production Relative to Average Sugar and Ethanol Prices<sup>24</sup>**



Source: Copersucar, Bloomberg

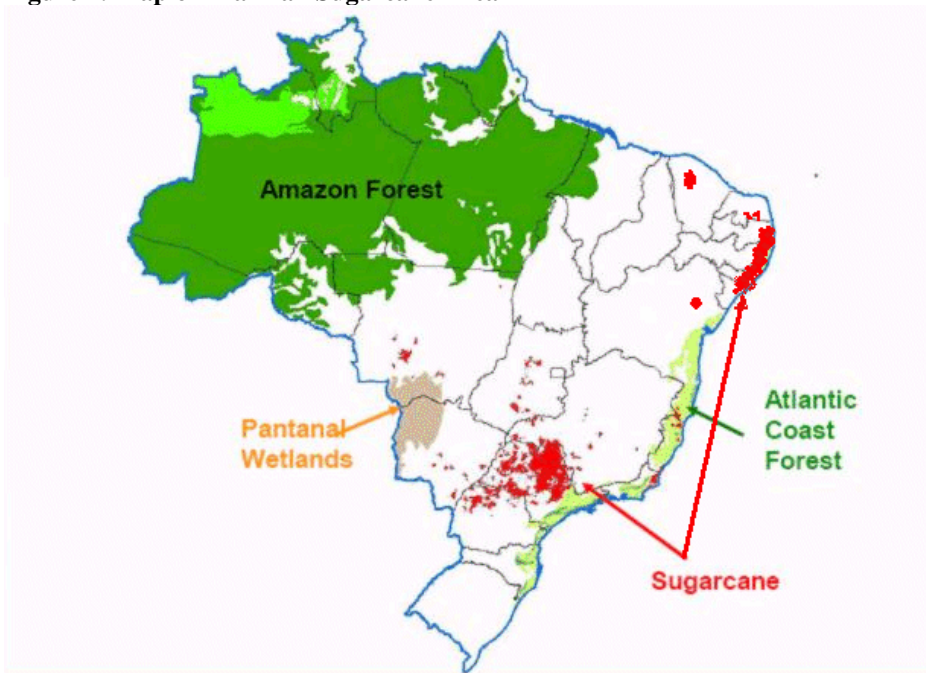
Sugar and ethanol are produced in two main areas in Brazil: the Center-South (CS) which produces 85 to 90% of national ethanol production and is concentrated in Sao Paulo state; and the North-Northeast (NNE) which produces 10 to 15% of national production. The two regions are geographically distant and have different crop cycles, and as a result their sugar and ethanol markets operate separately and vary significantly in price. The NNE has consistently higher sugar and ethanol prices, reflecting the relative scarcity of alcohol in the region as well as the cost of transporting supplies from the Center-South.

The NNE has the benefit of 2-3 days less sailing time to Europe, North America and Asia, yet sugarcane production has remained relatively static in the region for the past decade as yields are significantly lower than the 100 tonnes per hectare achieved in the Center-South. Current expansion is mainly concentrated in Sao Paulo state and the surrounding area, where most of the existing mills and expertise are concentrated, as well as the main consumer market for ethanol<sup>25</sup>. As improvements are made to transport systems it is anticipated that cane will gradually spread further to the Center-West.

<sup>24</sup> 0.36 metric tons of sugarcane produces 50kg of sugar or 7.8 gallons of ethanol. Therefore average sugar price is based on a 50kg bag, and average ethanol price is based on 7.8 gallons.

<sup>25</sup> Sao Paulo state has the highest GDP in Brazil and is the most densely populated.

**Figure 7: Map of Brazilian Sugarcane Area**



Source: Guinness Atkinson

Only 5.34 million hectares out of 320 million hectares of arable land (or 0.6% of total land area) are currently used for cultivating sugarcane in Brazil. This compares to U.S. arable land capacity of 135 million hectares, almost all of which is currently utilized, thereby severely constraining expansion of corn production for ethanol. In contrast Brazilian sugarcane farming is forecast to expand to 8 to 10 million hectares by 2015, yet this will still represent only 5% of the total area in Brazil suitable for sugarcane planting.

**Table 1: Brazil's Land Capacity (millions of hectares)**

Brazil's Territory	~850.00
Total Arable Land	320.00
Cultivated – all crops	60.40
Cultivated – with sugar cane	5.34
Cultivated – for ethanol	2.66

Source: Guinness Atkinson, Embrapa

Despite Brazil's abundance of available arable land there is an international misconception that the development of the Brazilian biofuel industry is causing deforestation (in particular of the Amazon rainforest<sup>26</sup>) and intrusion into the Brazilian Cerrado<sup>27</sup>. However, these concerns are largely unfounded as current plans for expansion are overwhelmingly on large tracts of land in Brazil that are already degraded after decades of cattle grazing, and the main sugar cane regions in Brazil are 1000 miles south of the Amazon. Cultivating sugarcane in the rainforest's tropical climate does not

<sup>26</sup> Much of this concern stems from the advance of plantations into many remaining remnants of the Atlantic Forest in the 1970s, which now covers just 7% of its original extent.

<sup>27</sup> The most biodiverse savannah in the world. Located directly east of the Pantanal wetlands (see Fig. 6).

make agronomic, economic or technical sense as yields are roughly half those achieved in the Center-South<sup>28</sup>. As a result, to date there have been no intrusions of sugarcane into the rainforest and there is neither a direct, nor indirect land-use change pressure coming from the cane<sup>29</sup>.

### **3. Outlook for the Brazilian Sugar-Ethanol Industry**

The Brazilian sugar-ethanol industry seems to be on a high growth trajectory. In the past control of the industry was dispersed among smaller business: sugar mills were owned by individual owners (farm or farm consortia) who controlled both cultivation and milling, with the mills located near the sugarcane fields. However, as the industry grows it is undergoing a process of increasing concentration and vertical integration as large corporations buy out smaller companies and invest in land and production. Many of these larger companies are multinational agribusiness corporations, and although the participation by foreign capital in the production of sugar and ethanol is currently only 4.5% this number is forecast to grow.

Many foreign groups are looking to invest in this industry as Brazil currently has the lowest costs of sugar-ethanol production in the world, as well as being the 10<sup>th</sup> biggest economy and one of the biggest consumers of fuel ethanol. While the price of oil stays above \$50/barrel, investors are expected to continue to compete for ethanol producing assets, bidding up prices. Brazil is an attractive investment opportunity at present as recent economic reforms have led to significant improvements in economic performance<sup>30</sup>: falling inflation, a reduction in public debt, a primary surplus and a floating interest rate. This is raising standards of living, boosting demand for cars (in particular FFVs) and taken with high oil prices this continues to boost demand for ethanol domestically. The local market is therefore expected to absorb much of the new ethanol production coming onstream.

However, in the longer term high capital values, high interest rates, rising production and transport costs and increasing logistics problems threaten to close the gap between the ethanol price and production costs, unless crude oil prices keep rising fast than the cost of producing ethanol. The main weakness of the sugar and ethanol sector in Brazil is inadequate transportation and port infrastructure, in spite of the great potential of the more competitive and sustainable modes of transport, such as waterways, pipelines and railways. The strengthening Brazilian currency will also erode some of Brazil's international competitiveness and the return that exporters receive on sales. Despite these concerns there has been no noticeable impact on exports as yet and the hope of many investors is that Brazil will become a 'green Saudi Arabia', supplying the world with a new alternative to fossil fuels (FT, 3/7/07). However, there is a big obstacle to export growth in the form of subsidies and tariffs that protect the less efficient ethanol producers in developed markets (most notably the U.S.).

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<sup>28</sup> International Energy Coordinator, U.S. State Department, as cited in Biopact, July 2007.

<sup>29</sup> U.S. Department of Energy, as cited in Biopact, July 2007.

<sup>30</sup> Domestic economic growth is currently at 4.5%.

## 4. Market Drivers

### **Energy Efficiency of Sugarcane Ethanol**

Sugarcane ethanol has a very strong energy balance at between 8.3 and 10.2 to 1<sup>31</sup>. This high positive balance is largely due to the agro-ecological circumstances in the tropics (sunshine, rain and multiple harvests), combined with the special nature of the crops<sup>32</sup>, meaning that only about 10% of the energy contained in sugar cane is needed to make ethanol, while the equivalent of 25% or more of the energy contained in most other plants is needed to process them into fuel. Furthermore, Brazil has been developing its ethanol industry for over 30 years, and the EROEI<sup>33</sup> has improved over time as Brazilian agronomists and technical personnel have gained knowledge in the field.

**Table 2: Net Energy Yield of Ethanol**

<i>Raw Material</i>	<i>Energy Output<sup>34</sup> / Energy Input</i>
Wheat	1.2
Corn	1-1.3 <sup>35</sup>
Sugar Beet	1.9
<b>Sugar Cane (Brazilian production conditions)</b>	<b>8.3-10.2</b>

Source: UNICAMP

The positive energy yield also carries over to greenhouse gas (GHG) emissions: when compared to gasoline the reduction of emissions per kilometre is estimated at between 85 to 90%. Ethanol from high-yielding Brazilian sugarcane is the most efficient biofuel currently under commercial production, relying on far less fossil fuel inputs than biofuel crops grown in more temperate climates. Furthermore, transporting biofuels from the South to the North in tankers does not alter the energy and GHG balance in a significant way<sup>36</sup> because of the low percentage of gasoline used to transport ethanol in tankers compared to the volume of ethanol on board. Northern countries can therefore import biofuels from the South in order to meet GHG reduction targets:

*"Ethanol produced in Brazil, even when it is imported by Europe [taking into account the energy needed to transport the fuel across the Atlantic] makes sense. If the United States and Europe are serious about biofuels, they must turn to the South for their supplies".* Claude Mandil, Executive Director of the IEA, October 2006.

<sup>31</sup> Each unit of energy put into planting, harvesting and processing the canes produces 8.3 to 10.2 times more energy in the form of biofuel.

<sup>32</sup> Sugarcane is a grass crop that is highly efficient in converting solar energy into sugar-rich biomass

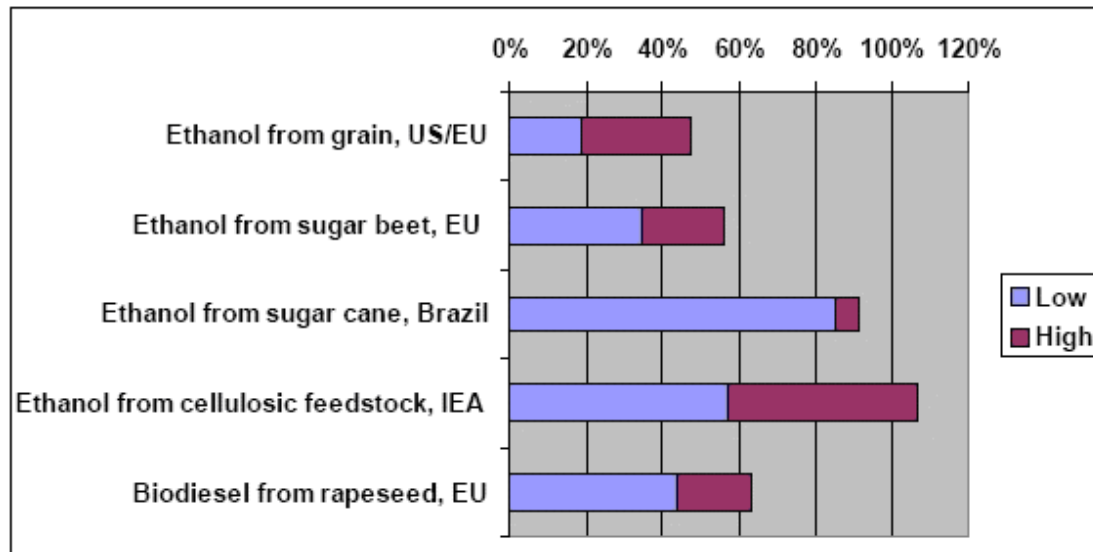
<sup>33</sup> Energy Returned on Energy Invested.

<sup>34</sup> Energy output includes the energy used in both production and refining.

<sup>35</sup> Estimates differ markedly for corn ethanol, and some researchers have even found a negative energy balance (although this is highly controversial).

<sup>36</sup> International Energy Initiative, 2006.

**Figure 8: Range of Estimated GHG Reductions from Biofuels**



Source: IEA, 2004, *Biofuels for Transport: An International Perspective*.

Figure 8 shows reductions in well-to-wheels<sup>37</sup> CO<sub>2</sub>-equivalent GHG emissions per kilometre from various biofuel-feedstock combinations, compared to conventional-fuelled vehicles<sup>38</sup>. Especially large reductions are estimated for ethanol from sugar cane<sup>39</sup> and from cellulosic feedstocks, and more recent studies tend to make estimates towards the higher reduction end of the range. This reflects efficiency improvements over time in both crop production and ethanol conversions.

### Comparative Agricultural Advantage

There is substantial available agricultural land in Brazil for growing sugarcane, estimated at 200 million hectares<sup>40</sup>. This provides a comparative international advantage (for example, over the U.S.) as Brazil can earmark new lands for sugarcane farming without reducing the food-crop farmed area or creating unacceptable environmental impacts. Brazil also holds one-fourth of the world's fresh water reserves, enabling large-scale irrigated farming and multiple harvests a year. Lastly, Brazil's location in the tropical and subtropical zones ensures intense solar radiation year-round; the basis of bio-energy production.

### Technical Expertise and Relatively Low Production Costs

In the 1980s and 1990s technological innovations, modern business practices and scale gains made possible by the Pró-Álcool Program combined to draw a learning curve that

<sup>37</sup> 'Well-to-wheels' refers to the complete chain of fuel production and use, including feedstock production, transport to the refinery, conversion to final fuel, transport to refuelling stations, and final vehicle tailpipe emissions. Domestic fuel consumption is assumed.

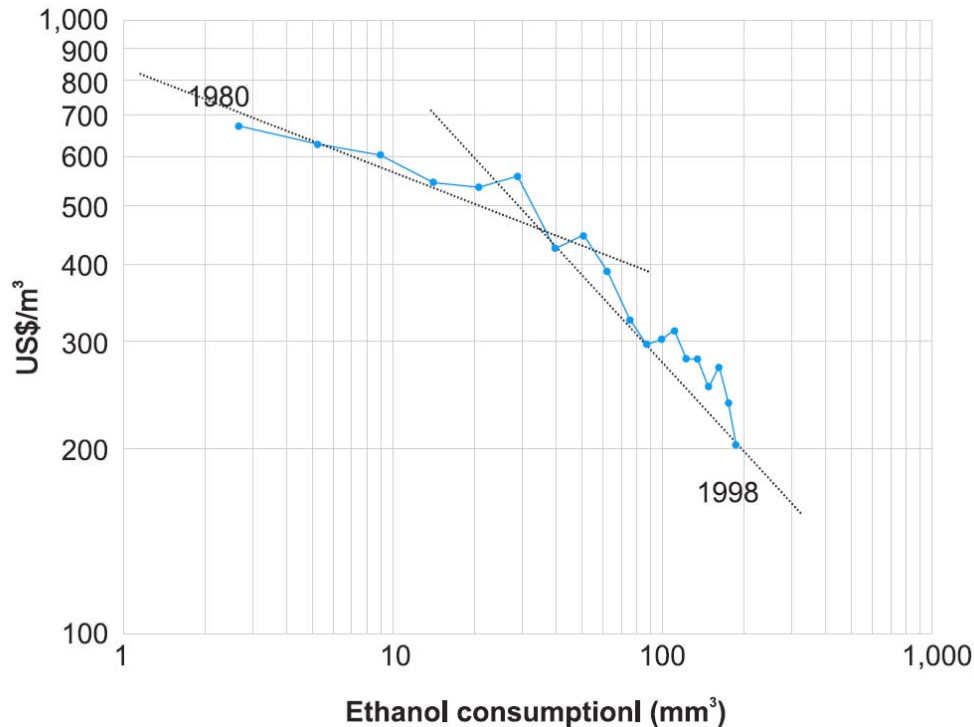
<sup>38</sup> Ethanol is compared to gasoline vehicles and biodiesel to diesel vehicles. Blends provide proportional reductions.

<sup>39</sup> Note that estimates for sugarcane ethanol are based on only two studies, resulting in the narrow range of estimates.

<sup>40</sup> Ministry of Agriculture, Livestock and Food Supply (2006), *Brazilian Agroenergy Plan: 2006-2011* Embrapa.

resulted in reduced alcohol production costs and prices compatible with those of gasoline. Brazilian producers have had to climb a steep learning curve, but today their efficiency and consequent cost reductions are nearly 75% higher than they were 25 years ago. As the graph below indicates between 1980 and 1998 the cost of producing one gallon of ethanol went from approximately \$2.57 to \$0.75<sup>41</sup>. Brazil currently produces at approximately \$0.70 a gallon<sup>42</sup>; a further reduction in the dollars to volume ratio of ethanol output from 1998.

**Figure 9: Learning curve of the sugarcane ethanol price**<sup>43</sup>



Source: Goldemberg, J. BNDES Seminar on the Competitiveness of Brazilian Ethanol, 2003

Improvements include the development of high-yielding sugar varieties, using remains of processed cane to power sugar and ethanol plants ('cogeneration') and using industrial waste from ethanol production to fertilize sugar fields. The development of cogeneration technologies is a particularly positive development in the industry as it reduces or eliminates energy costs. Waste can also be used for animal feeds and paper manufacturing, and technologies to produce ethanol from bagasse hydrolysis are also being developed and could become commercially viable in 10 to 15 years<sup>44</sup>.

<sup>41</sup> From \$680/cubic meter to \$200/cubic meter.

<sup>42</sup> About half current U.S. production costs.

<sup>43</sup> The y-axis shows the amount of U.S. dollars spent to produce one cubic meter of ethanol (\$100/ m<sup>3</sup> = \$0.38/gallon), while the x-axis shows cumulative ethanol consumption in millions of cubic meters (1 million m<sup>3</sup> = 264.172 million gallons) over time.

<sup>44</sup> Ministry of Agriculture, Livestock and Food Supply (2006), *Brazilian Agroenergy Plan: 2006-2011* Embrapa.

Much of this progress comes from Brazil's centre of sugarcane research: the Centro de Tecnologia Canavieira, located in Sao Paulo. Here researchers identify which variety will grow best in which part of the country, where to locate new fields and the best time to harvest. Over the past 20 years, the center has developed some 140 varieties of sugar, which has helped lower growing costs by more than 1% a year.

**Table 3: Ethanol Fuel Yields per Acre**

<i>Crop</i>	<i>Gallon per acre</i>
Corn (US)	354
<b>Sugar cane (Brazil)</b>	<b>662</b>
Sugar beets (France)	714

*Source: Centro de Tecnologia Canavieira*

As a result of these innovations the productivity and profit margins of Brazil's ethanol producers have steadily increased. The U.S. is still further along in cellulosic research and benefits from much bigger investments, but Brazil has the advantage of immediate availability of sugarcane. As a result the U.S. and Brazil have agreed to cooperate in developing an international market for ethanol, despite being in opposite positions. Brazil is preparing to turn its 32 year experience of domestic ethanol development into a large-scale export programme, while the U.S. will have to rely on massive ethanol imports to achieve its goal of cutting gasoline consumption 20% by 2017.

### **Domestic Policy and Institutional Support**

Brazil is committed to a diverse energy matrix, with a high proportion of energy coming from renewable sources. 30% of the 145 million tonnes of oil equivalent consumed in Brazil in 2006 came from sugar cane, wood, charcoal and other renewable bio-mass sources, and plans are being made to increase this share to a third by 2020. This policy commitment provides a strong market driver for domestic biofuel demand.

**Table 4: World Energy Supply**

<i>Country</i>	<i>Primary energy supply</i>	<i>Renewable energy</i>	<i>Renewable energy (%)</i>
Argentina	57.6	6.2	10.8
Australia	115.6	6.6	5.7
<b>Brazil</b>	<b>185.1</b>	<b>66.4</b>	<b>35.9</b>
Germany	351.5	9.2	2.6
United Kingdom	235.2	2.5	1.1
United States	2,281.4	99.1	4.3
<b>World</b>	<b>10,038.3</b>	<b>1,351.9</b>	<b>13.5</b>

*Source: Ministry of Agriculture, Livestock and Food Supply (Brazil), 2006*

Although the government no longer provides direct subsidies to the ethanol industry, the gasohol mandate provides consistent demand and the government is investing \$ 37.5 billion in the current sugarcane harvest as well as providing low cost debt to the sector (substantial credit and reduced interest rates). Furthermore, there is a tax reduction for hydrated ethanol cars<sup>45</sup> and there are several government institutions that provide

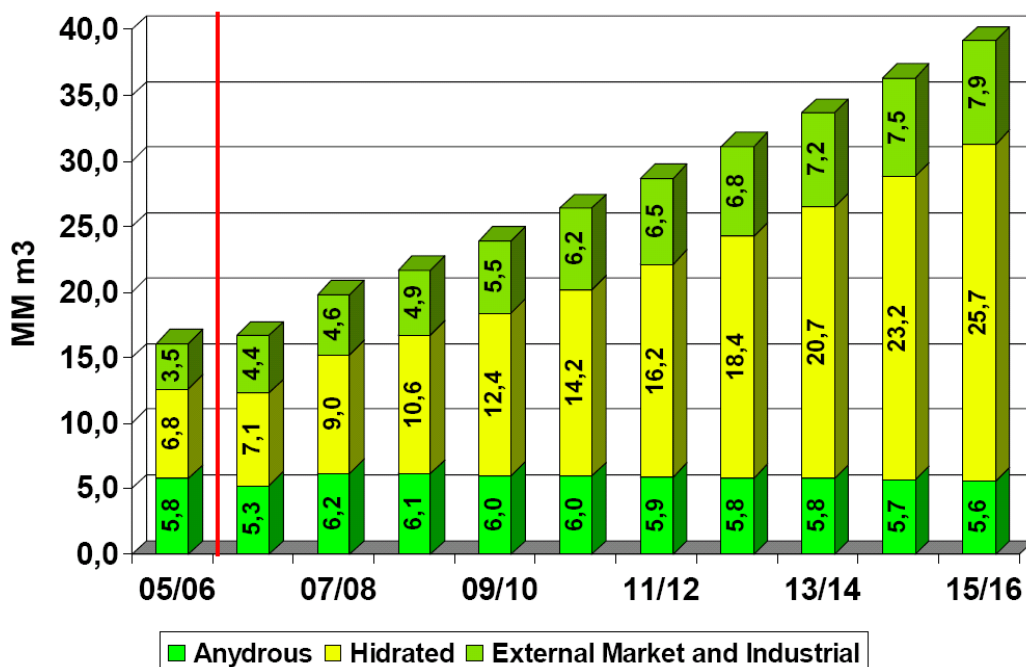
<sup>45</sup> This is the only remaining government incentive from the 1975 Pró-Álcool Program.

research and technological support to the sugar-ethanol industry; most notably Embrapa: the Brazilian Agricultural Research Corporation.

### Size of the Domestic Market

The Brazilian domestic ethanol market is sufficiently large enough to enable scale gains that reinforce competitiveness and support its expansion into the world markets<sup>46</sup>. Domestic demand is projected to grow at 24.3% per annum<sup>47</sup> in coming years, driven by favourable government policy, high oil prices and growing popularity of FFVs. As Figure 10 indicates, Copersucar projects total 2015/16 demand to be over 10.3 billion gallons: 1,480 million gallons of anhydrous, 6,790 million gallons of hydrous and 2,085 million gallons for the external and industrial markets.

Figure 10: Forecast of Brazilian Ethanol Demand<sup>48</sup>



Source: Copersucar Presentation, 2007.

Hydrous ethanol is expected to account for most of the projected increase in ethanol demand. This is because Brazilian FFVs can operate on anything up to 100% hydrous ethanol, and as the proportion of FFVs in Brazil's automotive fleet increases so will demand for this type of fuel. Production of hydrous ethanol is also forecast to increase as it is less expensive to produce than anhydrous ethanol, and a relatively low hydrous ethanol price versus gasoline price will give drivers the incentive to use hydrous ethanol rather than gasohol. The government mandated blend of ethanol in gasohol targets the anhydrous ethanol market, explaining why projected demand for this type of fuel is relatively static.

<sup>46</sup> Ministry of Agriculture, Livestock and Food Supply (2006), *Brazilian Agroenergy Plan: 2006-2011* Embrapa.

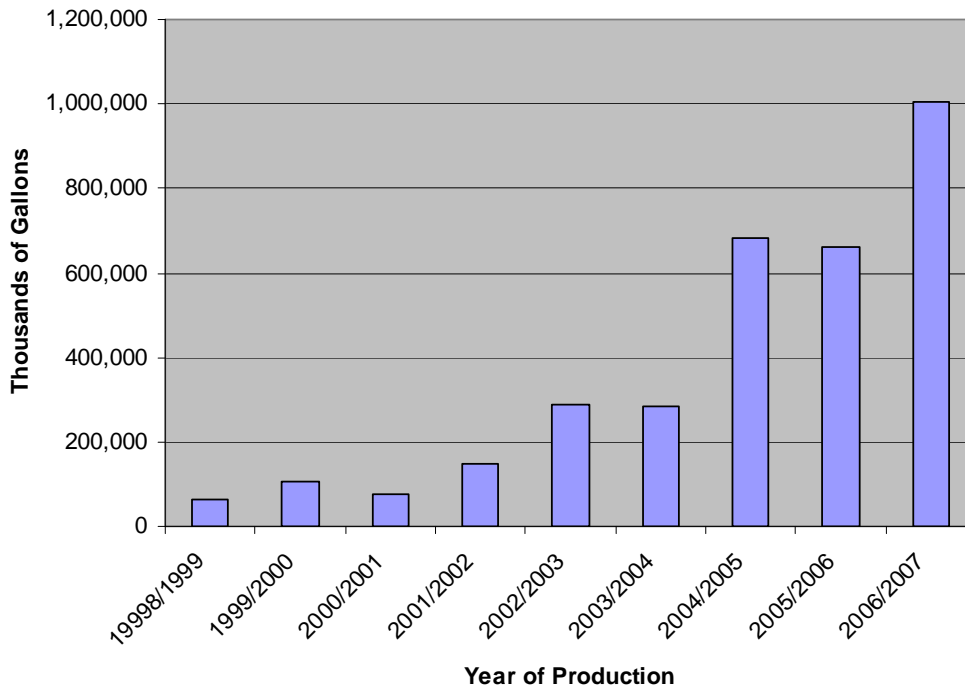
<sup>47</sup> See Figure 10, Copersucar, 2007.

<sup>48</sup> Where 1 MM m<sup>3</sup> (million m<sup>3</sup>) = 264.172 million gallons.

### Growth of Foreign Market

Brazil has led the external ethanol market and will remain the leader should current trends continue. Except for a slight blip in 2005/2006 exports have grown annually, reaching 20% of total production in 2006, or 900 million gallons of sugarcane ethanol<sup>49</sup>. Exports have been mainly to the U.S. in 2006/2007, with smaller quantities shipped to Central America and the Caribbean, India, Asia and Africa.

Figure 11: Total UNICA<sup>50</sup> Ethanol Exports, 1998 to 2007



Source: UNICA Statistics

Ethanol as an additive to gasoline is becoming increasingly popular in countries outside Brazil; including the USA, the EU, Mexico, India, Argentina, Colombia and more recently Japan. The U.S. imported 433.7 million gallons of Brazilian ethanol in 2006 despite a \$0.54 import tariff per gallon, and if the U.S. is to meet its ambitious renewable fuel targets imports are likely to increase as domestic production is constrained by corn availability and price. Similarly Japan is set to become a key importer of Brazilian ethanol following a provisional agreement between Petrobras and Japanese trader Mitsui to exclusively export the product to Japan. The agreement comprises minority stakes in 5 Brazilian ethanol mills to secure annual exports of hundreds of millions of gallons of ethanol to Japan<sup>51</sup>. The mills are scheduled to be operational by the end of 2009,

<sup>49</sup> UNICA Ethanol Export Statistics.

<sup>50</sup> Uniao do Agroindustria de Cana de Acucar.

<sup>51</sup> Petrobras, Mitsui to buy stakes in 5 ethanol mills. Market Watch, June 26, 2007.

although the agreement is dependent on the Japanese government setting binding targets for ethanol content in gasoline<sup>52</sup>.

### **Environmental and Health Benefits**

Ethanol is a renewable fuel that minimizes dependency on unstable oil producing countries, reduces CO2 emissions<sup>53</sup> and emissions of particulates, and eliminates sulphur dioxide. The use of ethanol in vehicle fuel noticeably improves urban air quality, providing a strong market driver in global demand for renewable fuels. The Kyoto Protocol is further driving this demand.

**Table 5: Examples of Ethanol Policies by Country**

<b>Country</b>	<b>Ethanol Policy</b>	<b>Date of Mandate</b>	<b>Imports from Brazil</b>
<b>USA</b>	Minimum content in some states 35m gallons renewable fuel by 2017	Multiple Proposed	433.7 million gallons (2006)
<b>Sweden</b>	5% ethanol in fuel 10% ethanol in fuel	2006 Proposed	Imports 85% of its ethanol from Brazil
<b>Colombia</b>	5% mix of ethanol in fuel 15% mix by 2010	2006 Proposed	Not currently, but production will not meet demand in 2008.
<b>Japan</b>	3 – 10% minimum content. New cars: 10% ethanol capacity	Proposed 2006	59.5 million gallons (2006)

*Source: Guinness Atkinson*

## **5. Market Risks**

### **Weather**

Domestic and international weather events are critical to producer productivity, sugarcane and ethanol prices and international demand. Domestic weather heavily impacts on how much sugarcane is grown. A slight weather variation, especially during harvest time, impacts on both crop yield and the sucrose content of the cane, affecting sugarcane prices and the efficiency of ethanol production. Similarly international weather events can have marked effects on international ethanol prices. Hurricane Katrina, for example, resulted in a sharp spike in U.S. ethanol prices in late 2005.

<sup>52</sup> *Petrobras, Mitsui to buy stakes in 5 ethanol mills.* Market Watch, June 26, 2007.

<sup>53</sup> The use of only 10% ethanol blends reduces greenhouse gas emissions by 18-29% compared with conventional gasoline (Renewable Fuels Association, 2007).

**Figure 12: Historic US Ethanol Prices, 2000-2007 (US\$/Gallon)**



Source: Bloomberg

### **Growth Constraints**

A study by state-owned Brazilian development bank BNDES found that Brazil needs an additional 100 new ethanol mills by 2010 just to supply the country's fast growing FFV market. Brazil has 77 new confirmed projects but may need an additional 23 by 2010 to meet domestic demand. Similarly, for Brazil to achieve its lofty export goals increased ethanol production is essential, with experts assuming a 40% increase in output per hectare of sugarcane based on development of new hydrolysis technology. Whether Brazil can achieve this near term growth is an issue of debate, in particular projected export growth which may be constrained by domestic demand given the penetration of flex fuel vehicles and tight supply availability.

### **Inadequate Infrastructure and Investment**

Brazil is a continental country with few railways and navigable rivers, and most goods are carried by road, many over very long distances. Existing logistics infrastructure cannot support projected growth in domestic and international demand, and there is a need for further investment in ethanol infrastructure to boost supply: pipelines, warehouses, new mills, industrial and agricultural equipment and port improvements.

The limited storage capacity of ethanol is also a critical supply risk both domestically and internationally. Domestically, ethanol cannot be transported or stored further inland than Sao Paulo as there is a lack of infrastructure and storage facilities. This limits domestic demand and explains why FFVs are not being used to their full capacity outside of Sao Paulo state. Similarly, ethanol consumption is limited in the U.S. and Europe as it cannot be stored in local ports due to finite storage capacity. The logistics of ethanol distribution is such that ships can arrive at their destination port and be unable to unload the product into storage tanks. Such supply interruptions are costly and damaging to the industry's reputation for reliability. Storage constraints also limit production and profitability, particularly in periods of high ethanol prices when refiners are prevented from producing at maximum output due to a lack of storage space.

### **High Cost of Transport**

It is not economic to transport sugar cane (bulky and relatively low value) more than about 25 km from fields to mills. Similarly, it is not economic to transport sugar and ethanol very long distances to ports and centres of population. Mills in close proximity to the sugarcane plantations, domestic market and international ports are therefore at a logistical and financial advantage. This helps explain why the sugarcane and sugar-ethanol industry is concentrated in Sao Paulo state.

### **Exports: Role of Domestic and Foreign Governments**

The U.S is potentially the largest market for Brazilian ethanol, although it currently imposes a \$0.54 tariff and a 2.5% ad valorem tax on Brazilian ethanol imports in order to encourage domestic corn ethanol production. There is concern that allowing Brazilian ethanol to enter the U.S. market without taxation will undercut the budding ethanol industry in the United States. This has encouraged Brazil to export to America via Caribbean and Latin American countries that qualify for both tariff and add valorem tax exemption under the U.S. government's Caribbean Basin Initiative (CBI). As a result, recorded hydrous ethanol exports to El Salvador, Jamaica, Trinidad, Tobago and Costa Rica are actually destined for the U.S. market, after being dehydrated in Caribbean Basin countries.

However, some direct anhydrous exports do occur when gasoline or ethanol prices spike in the U.S. relative to Brazil<sup>54</sup>. These direct exports tend to be sporadic, only lasting a maximum of a few months after which trade stops for extended periods. The Brazilian government also partly controls ethanol exports to ensure that domestic demand is fulfilled. For example, the government may raise or lower the anhydrous ethanol mandate in order to restrict or promote exports. As a result of these variables export rates are not constant and producers cannot make export decisions based solely on relative prices.

### **International Competition**

A growing number of countries are developing or expanding their ethanol capabilities: the U.S., Europe (particularly Germany, Sweden and France), China<sup>55</sup>, South Africa, the Caribbean (Jamaica), Central and Latin America (Colombia, Costa Rica, Guatemala), India and Canada. Unlike in previous years, in 2006 smaller ethanol producers grew production even faster than the U.S. and Brazil<sup>56</sup>. China increased output nearly 70% in 2006<sup>57</sup>, and European ethanol production grew by 71% as governments implemented more financial incentives and mandatory gasoline blending targets. German production more than doubled to overtake Sweden and become Europe's leading producer, and output in Canada and India also grew substantially.

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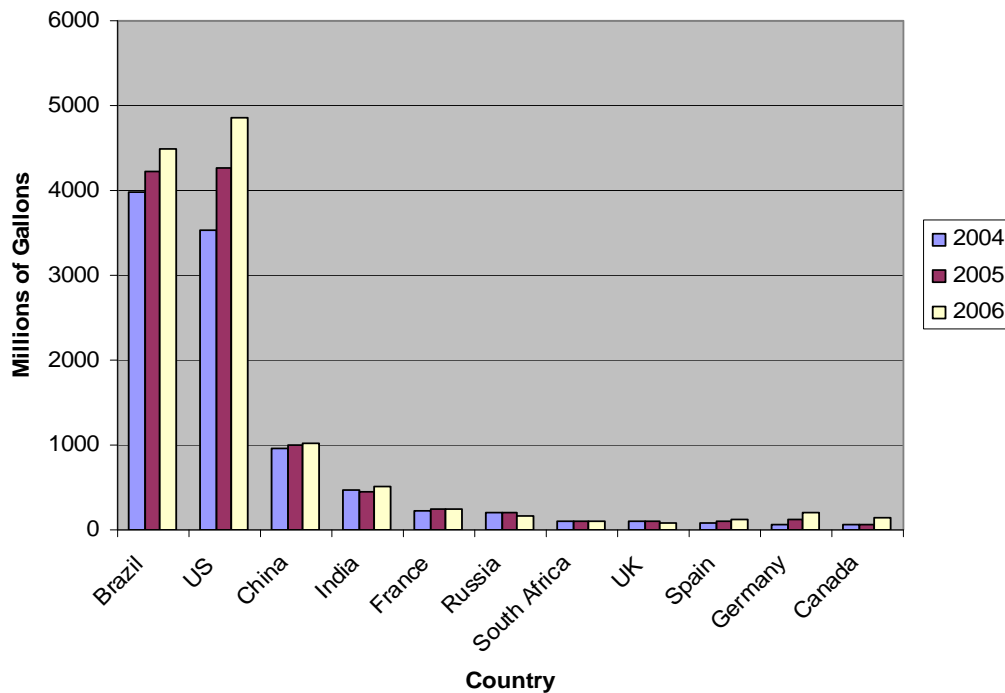
<sup>54</sup> See Figure 1.

<sup>55</sup> However China announced a moratorium on the production of ethanol from food crops due to rising costs of corn and grain. The government has asked producers to switch to non-food crops such as cassava and sorghum.

<sup>56</sup> The U.S. and Brazil accounted for 89% of total ethanol production in 2006, down from 93% in 2005.

<sup>57</sup> China now accounts for 4% of world production.

**Figure 13: Annual World Ethanol Production by Country, 2004-2006**



Data source: Renewable Fuels Association.

However, despite this growth in global supply Brazil remains the lowest cost producer and largest global exporter of ethanol, accounting for 44% of global supply in 2006. No other country in Latin America or the Caribbean currently exports domestically produced biofuels to the U.S. because in these countries it is currently more economical to produce sugar than ethanol. Nonetheless, spurred by publicity about ethanol’s benefits and the interest of foreign investors, governments and investors throughout the Latin America and Caribbean are moving ahead with plans to turn sugarcane into ethanol for export or to replace 5 to 10% of gasoline in domestic vehicles. The U.S. and Brazil are providing technical assistance to many of these countries in an attempt to accelerate ethanol production efforts throughout the region.

**Table 6: Ethanol Activity in Latin America and the Caribbean**

Country	Ethanol Activity
Dominican Republic	Foreign companies are investing to produce sugarcane ethanol by 2008.
Guatemala	Accounts for half of the sugar produced in Central America, and currently have five sugar ethanol plants in operation. Export sugarcane ethanol to Europe.
Guyana	A Brazilian company is planning to produce sugarcane ethanol.
Nicaragua	Began exporting sugarcane ethanol to Europe in 2007.
Peru	Will export sugarcane ethanol to U.S. by 2009.

Source: Guinness Atkinson

### World Fuel Ethanol Surplus

Inflated U.S. ethanol prices in 2006 resulted in a strong production surge in the U.S. and Brazil. These production increases have caused industry analysts to increase their forecasts for the world fuel ethanol surplus. For example, Kingsman have nearly doubled their 2007 forecast from 345 million gallons in March 2007 to 630 million gallons in June 2007<sup>58</sup>. This growth in production and the world surplus is reflected in depressed second quarter 2007 ethanol prices.

### **Dependence on Gasoline and Sugar Prices**

As previously outlined ethanol demand is highly sensitive to gasoline prices, and ethanol production to sugar prices.

### **Environmental and Social Concerns**

There are some grassroots and NGO movements against the expansion of sugar-ethanol production in Brazil. Their concerns include:

- Decline of soil quality due to poor sugar farming techniques and lack of crop rotation
- Expansion of the farm frontier into Amazon forests, especially as land prices increase<sup>59</sup>
- Sugarcane burning: 60% of cane fields are burnt in order to facilitate cutting, causing air pollution and associated human health risks
- Depletion of water supplies as each litre of ethanol requires 30 litres of water
- Human rights issues: the Brazilian sugarcane industry has a poor human rights record due to accusations of worker exploitation and slave labour
- Concerns over large scale land ownership (especially by multinationals): land and income inequality, regional vulnerability to sugar/ethanol market downturns, marginalisation of other crops and soil degradation from monoculture

Many of these concerns arise from a lack of official capacity to regulate the industry, and many are focussed on future rather than current issues. In order to promote exports and attract foreign capital the government is now taking these concerns seriously and promoting responsible and controlled development of the industry. For example, the government has banned cane burning between 6am and 8pm until October 2007, and this is likely to be extended to a full ban due to continued dry weather this year<sup>60</sup>. Similarly, the government has responded to human rights concerns by announcing that companies exporting ethanol in 2008 will need a new environmental and industrial standards certificate<sup>61</sup>. This certification will be overseen by Inmetro<sup>62</sup> and will guarantee cane plantations are not using slave labour.

## **6. The Process of Sugarcane Ethanol Production**

### **1. Extraction**

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<sup>58</sup> *World Fuel Ethanol Balance 2007: Second Estimate*. Kingsman, July 5, 2007.

<sup>59</sup> See earlier discussion in Section 2.2.

<sup>60</sup> Kingsman Ethanol News Summary, August 1, 2007.

<sup>61</sup> Dow Jones, July 19, 2007.

<sup>62</sup> The National Institute of Meteorology, Standardization and Industrial Quality.

The sugarcane must be broken up to make the juice more easily accessible; this is typically accomplished using a three-roller press. The juice is then collected and the leftover bagasse, comprised mostly of sugarcane stalks and water, can be burned in boilers to co-generate power for the processing plant<sup>63</sup>.

## **2. Purification**

There are a number of impurities contained in the juice once it is extracted, including dirt and small pieces of bagasse. Once extracted, the juice is typically filtered through a variety of methods such as straining, sedimentation and centrifuge force. It is then chemically treated, heated and put through a process of evaporation to extract excess water.

## **3. Saccharification**

Lime is added to the juice mixture and the liquid is then heated and cooled again. After this phase the juice is pasteurized and sterilized.

## **4. Fermentation**

The sugars are transformed into ethanol and carbon dioxide through a biochemical process where yeast is added to ferment the sugars. This process includes several stages of fermentation and can last from 4-12 hours. Afterwards, the yeast is removed from the ethanol by centrifuge.

## **5. Distillation**

The mixture now contains 7-10% alcohol and unfermented solids. It is processed in a series of distillation columns to remove the unfermented matter. The ethanol leaves through the top of the final column with a strength of 96%, and the leftover phlegm leaves through the bottom of the final column. At this stage, ethanol contains some small percentage of water, typically 4%, and is called hydrous ethanol.

## **6. Dehydration**

To achieve maximum strength ethanol, the 96% mixture is dehydrated using benzol, which is later removed, leaving a mixture of 99.7% ethanol, called anhydrous ethanol.

The information provided herein represents the opinions of Tim Guinness, Edward Guinness, and Matthew Page and is not intended to be a forecast of future events, a guarantee of future results, nor investment advice.

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<sup>63</sup> This reduces energy costs.