LIQUID BIOFUELS IN BRAZIL

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ABSTRACT: This paper seeks to show the evolution of both the production and use of ethanol in Brazil, characterizing its importance among the liquid fuels in the country. At the same time, it qualifies the competitiveness of ethanol in Brazil under the current conditions, presenting the positive externalities of the renewable product and scenario-based demand projections. At the end, it seeks to characterize the fundamental works on the consolidation of ethanol as an international commodity.

It was only in the 20th century when liquid energy was effectively used in vehicles, where ethanol, as a fuel, was the basis for the studies of the German inventor Nicolaus August Otto at the end of 19th century. The production and use of ethanol in Brazil was all based on the competitive culture raw material sugar cane, the main product of which in the beginning of the 20th century was sugar, and ethanol was already a balance factor for the overage of that raw material in face of the limitation of the Brazilian internal market. This strategy yielded good results for the development of today´s modem Brazilian renewable ethanol as a fuel and gave high competitiveness level for the sugarcane of the agribusiness sector.

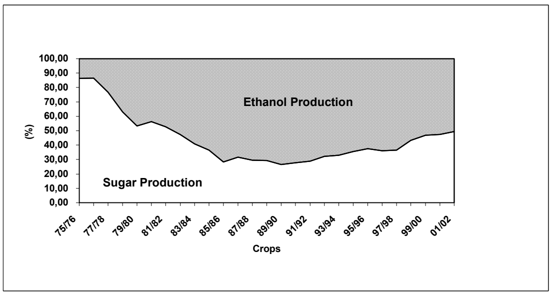

Figure 1: Sugarcane: Sugar and Ethanol Production in Brazil

The short history of the liquid energy in Brazil (one century), renewable ethanol in this case, had two clear development phases: a) The use of anhydrous alcohol as a gasoline additive (since 1920) for the various kinds of vehicles (now 60% of the total); b) The use of hydrated alcohol as the sole fuel in dedicated vehicles (now 40% of the total).

Today, Brazil has around 19 million vehicles running with Otto Cycle engines (gasoline and ethanol), where, roughly, 16 million are "gasohol" and 3 million are ethanol driven cars.

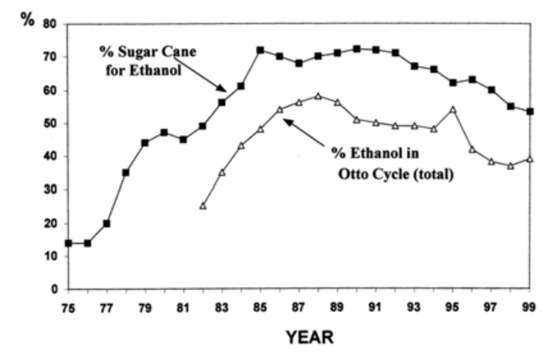

Figure 2: Ethanol and Gasoline Utilization

As it is possible to see, the importance of ethanol in the consumption of fuels in Brazil is highly relevant. Today it represents 40% of the Otto Cycle, after having reached nearly 60%.

Anyway, Brazil is a continental country where highways are extremely important, that is, gasoline (with ethanol), ethanol and diesel have a great impact on the national development. The advantages as a gasoline additive when compared with MTBE are clear: a) Approximately twice as much oxygen; b) Greater latent vaporization heat; c) Better octane rating; d) Less air required for combustion; e) Lower reactivity in the atmosphere; f) Lower toxicity; g) Biodegradability in water and soils; h) No highly offensive odor; i) Produced from renewable raw materials; j) It consumes (by substituting for gasoline) a lot less CO_2 than it gives out (in the case of Brazil, uptake 20% from all CO_2 emitted by the fuel cell products).

The evolution of both the production and consumption of alcohol in Brazil shows the times of transition from the present reality:

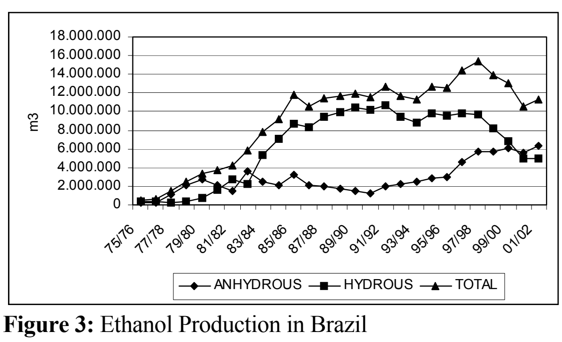

Figure 3: Ethanol Production in Brazil

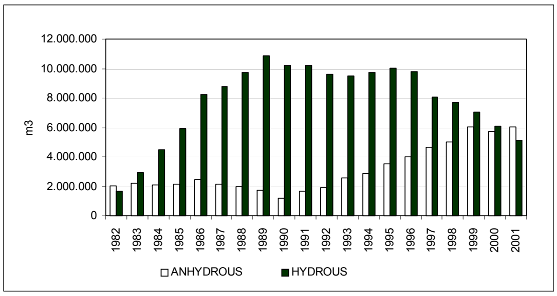

Figure 4: Fuel Ethanol Consumption in Brazil

There are two explanations for the consumption curves: while the anhydrous ethanol consumption increases in the face of the increase in both gasoline car sales and the percentage of anhydrous ethanol content of gasoline, the demand for hydrous ethanol falls in the face of the scrapping of the ethanol fleet.

As to the ethanol fleet, sales have been experiencing growth since 2001, regardless of the lack of policies to support it.

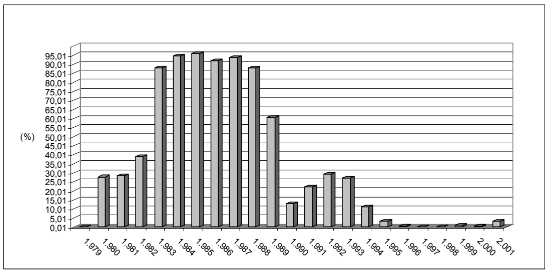

Figure 5: Brazil – Ethanol Cars and Light Commercial Cars: Sells in the Internal Market

It is important to point out the main efforts in the USA (Illinois) and Europe (Sweden), which are also shared in Brazil, in testing fleets for the use of ethanol directly in diesel (with additive) or in biodiesel (seed oil transesterified with ethanol). The sugar cultures currently rule the ethanol production market worldwide:

Table 1: World Ethanol Production[(1)] by Feedstock

Feedstock	%
Sugar Crops	59
Grain	32

Note: (1) 31 bln liters in 2001
Source: Berg, C, The Outlook for the World Sugar and Molasses Market, Power Crops for the Americas, Miami, April/2002

The maintenance, expansion of or the resource for this trend in the future will depend on the competitiveness degree of the raw materials, the availability and potential of the lands for production, and the global and national public policies implemented.

This is an extremely relevant point for the future of the biomass as a liquid fuel. The competitors, in this case, would be gasoline and diesel. In the case of gasoline, its current international price (N.Y. base) is US$ 32 per barrel at the Brazilian refinery; the current cost of anhydrous alcohol at the Brazilian producer is also US$ 32 per barrel:

Table 2: Ethanol´s Competitiveness - Brazil

US$ 1 = R$ 2,50	Anhydrous Ethanol	
Producer – Sale Price (R$/l)	0,60	
Producer – Cost Price (R$/l)	0,50	
(US$/l)	0,24	0,20
(US$/b)	38,00	32,00
Base Relation (ethanol/gasoline)	1..00	
Gasoline Price (International Price) (US$/b)	32.00	
Gasoline Sales´ Price in Brazil (US$ / b)	64.00	

In the Brazilian case, the efficiency gains and cost reductions achieved since 1975 (in large scale), between 2 and 3% per year (average), are related to the well-known “learning curve”:

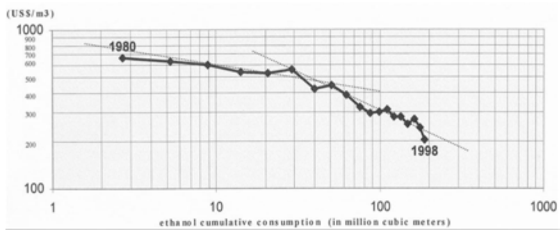

Figure 6: Ethanol Cost “Learning Curve”

The expectations for the future are promising. On the one hand, because the countries’ maturation on the planet heating issue and the importance of the transportation sector in this matter (>50%); on the other hand, due to the investments in R&D&D, which are making ethanol and biodiesel viable. In the Brazilian case, there are two scenarios in discussion for the case of ethanol:

a) Continuity, that is, with sales of ethanol driven cars near zero:

Table 3: Scenario 1: Fuel Ethanol Consumption without Ethanol Car Sales (bi l)

Crops	Anhydrous	Hydrous	Total
98/99	5,69	7,33	13,02
99/00	5,93	6,98	12,91
00/01	5,43	5,86	11,29
01/02	5,40	5,23	10,63
02/03	6,58	4,72	11,30
05/06	7,83	2,93	10,76
10/11	9,82	0,77	10,59

b) With ethanol car sales of around 15%, including, in this case, new technologies like the FFV (flexible fuel vehicles) for ethanol (100% ethanol or 100% gasoline or the desired percentage):

Table 4: Scenario 2: Fuel Ethanol Consumption with Ethanol (± 15%) or FFV Car Sales (bi l)

Crops	Anhydrous	Hydrous	Total
98/99	5,69	7,33	13,02
99/00	5,93	6,98	12,91
00/01	5,43	5,86	11,29
01/02	5,40	5,23	10,63
02/03	6,58	4,72	11,30
05/06	7,,49	4,53	12,02
10/11	8,93	6,02	14,95

The analysis of the differences between the scenarios points to over 4 billion liters in 2010, which is relevant.

The differentiated policies for alcohol are justified by the positive externalities of the product when it is compared with the fossil competitor.

There are various positive externalities of ethanol in Brazil. Two very objective examples are the number of jobs created by the kind of vehicle produced (gasohol or ethanol ones) and the CO_2 uptake by the "sugar cane system" in Brazil:

Table 5: Employments in the Production of the Vehicle and of Fuel Men-Year per Thousand Vehicles

Men Year Generated	Ethanol Vehicles	"C" Gasoline Vehicles	"A" Gasoline Vehicles
Vehicle Production	51,3	51,3	51,3
Fuel Production in 15 years of Average Life	1.482,0	369,9	18,8
Total Employments	1.533,36	421,2	70,1
Ratio of Employments per Type of Vehicle	21,87(1)	6,01	1(2)

(1) Considering that an alcohol driven vehicle consumes, on average, 2.600 liters of hydrated alcohol p/y, during average work life of 15 years, and that the production of one million liters of alcohol p/y, generates 38 direct employments on average in Brazil.
(2) Considering that a gasoline driven vehicle spends 20% less fuel than a similar alcohol vehicle, and that the production of one million liters of gasoline p/y generates 0.6 direct employments in the country. (Petrobrás had 41,173 employees in 1997, extracting 1 million barrels/day of petroleum and refining 1.45 million).
Souce: UNICA/ANFAVEA/Matriz Energética/Petrobrás

Table 6: Net CO_2 Balance in Brazil (1996)

	10^6tc (equiv)/year
• Fossil fuel utilization in the agri-industry	+ 1.28
• Methane emissions (sugarcane burning)	+ 0.06
• N_2O emissions	+ 0.24
• Ethanol substitution for gasoline	- 9.13
• Bagasse substitution for fuel oil (food and chemical industry)	- 5.20
• Net contribution (carbon uptake)	- 12.74

Source: Macedo, Isaias (1997)

Table 5 showed that what would be 1 job per vehicle (if Brazil had gasoline driven cars) means actually 6 jobs (because Brazil uses gasohol), and that there are 22 jobs/car when alcohol is the fuel.

Table 6 shows a CO_2 uptake that is equivalent to more than 20% of all of the CO_2 emitted by oil derivatives in Brazil.

The automobile issue in Brazil, as well as in other countries, indeed deserves global analyses.

In the case of Brazil, it was learned that, for a future in which hydrogen (and ethanol!) cars will prevail, flexibility is the magic word in the transition, not to mention the success of E 100 cars (having alcohol as the sole fuel). The following points will be fundamental to the intended evolution:

1) Variation of the anhydrous ethanol level in gasoline
In Brazil, the band that defines by law the level of anhydrous ethanol in gasoline ranges between 19 and 26%. This is an important supply and demand balancing mechanism that allows a flexible production.

2) Flexible fuel vehicles that work with any gasoline (E22) and hydrous ethanol mixtures
- Serving the consumer, who will be able to choose the fuel having a lower price or better performance;
- Technology already known (± 1.8 million vehicles in the USA);
- For the technology currently used in Brazil (stoichiometric mixture and 3-way catalyst), it would be an intelligent commitment solution between ethanol and gasoline (compression rate ~ of ethanol).

3) Stakeholders
The automobile assembling industries, autopart manufacturers, technology institutes and governmental agencies should combine their efforts to introduce solutions that meet the interests of consumers while defending the interests of the country and preserving the environment. It recommends government coordination.

4) R&D&D
Investment in R&D&D in the production and use areas.

5) International Mechanisms
Having international mechanisms to turn bio-fuels into commodities, with futures contracts in Stock Exchanges, with price and volume reference.