LETTER TO EDITOR

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The Potential of Ethanol Production from Sugarcane in Brazil

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Sugarcane is a wonderful crop plant. It converts solar energy into chemical energy at a very high efficiency rate. Traditionally, sugarcane is used primarily for sugar production. However, with the energy crisis that has struck our world, the sugarcane plant has emerged as a viable producer of bioenergy. Currently in Brazil, alcohol is the main product derived from sugarcane and sugar as the principal by-product.

Why Renewable Energy?

Renewable energy from plants is a clean energy while fossil oil energy is a polluting energy with time counting down to its depletion. In July 2006, the price of petroleum barrel surpassed previous records and reached US$70. This rising price signals the return of the petroleum crisis in an even bigger scale than the one which occurred in 1973, when the barrel price was around US$30. In addition, the time for depletion of this energy source is nearing. According to optimistic calculations, the global petroleum reserves are estimated at 2.2 trillion barrels and there are projections that production will reach at a peak of 80 million barrels per day sometime between 2010 and 2020. From there, production will tend to fall every year. At the same time, the demand will increase at an even higher proportion (Ethanol Guide, 2005). With the reduction of this fossil fuel, the price will inevitably go up. Some forecasts have already indicated a price of U$100 for a petroleum barrel within the next few years while Brazilian alcohol is already economically competitive against petroleum when oil price is above US$40 per barrel (O Estado de Sao Paulo - Economia, 2005). In addition, the economic growth of third world countries will further raise the demand for cars which use gasoline, a product of petroleum oil. This increase will correspond to the emission of more pollutants (Nehmi, 2004). Countries which have developed alternative energy programs, such as a renewable energy system like an ethanol program, will definitely have the greatest chance to survive this crisis on a global scale.

Why Sugarcane?

Sugarcane is the cheapest raw material for the renewable energy production (Dharmawardene, 2005). For the time being, Brazil is the world's largest sugarcane and ethanol producing country. The U.S.A. is the second largest ethanol producing country, using corn as the main raw material. Comparing sugarcane with corn, the sugarcane can yield 5000-7000 l/ha/year of ethanol while corn's ethanol yield is around 3000 l/ha/year (Table 1).

Energy balance of ethanol production from sugarcane in Brazil is more than 8.0 (Table 2) while that from corn is about 1.1 (Baldani, 2002; O Estado de Sao Paulo -Agricola, 2005). The interest of using ethanol as a renewable fuel is so great that ethanol production is recommended by many specialists in other countries even when it costs 3-5 times more to produce from beet or corn than from sugarcane in Brazil (Ethanol Guide, 2005).

Sugarcane as a raw material can contribute to the production of renewable energy in 3 ways. The first one is producing ethanol, either used directly as liquid fuel or used as a gasoline mixture. For 2005/2006, Brazil will produce 450.2 million tons of sugarcane and 182.8 million tons of this production will be used to produce fuel ethanol which equals approximately 17.5 billion liters (Ethanol Guide, 2005). This amount is well enough for internal fuel consumption for the time being. Although Brazil is the world's biggest and most competitive ethanol producer, its exportation is still small,

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Table 1. Alcohol production rates from different raw materials

Raw material	Production (t/ha)	Yield (l/t)	Yield (l/ha)
1. Sugarcane	80.0	75	6000
2. Corn	3.0	380	1140 (3420*)
3. Cassava	20.0	180	4500
4. Potato	20.0	130	2600

*Considering 3 harvests per year.

having exported about 5% of its production in 2004. As consumption increases in the future, Brazil will be well positioned to handle this demand. Moreover, Brazil has a history of flexibility in mixing this biofuel to gasoline and where the factories can also easily change the proportion of sugar or ethanol production according to the market's necessity. The second one is bagasse which is used as a fuel or as the cogeneration of electric energy. The bagasse from each ton of

Table 2. Average energy balance of ethanol production from sugarcane in Brazil (Baldani, 2002)

ITEM	Average Energy Balance (MJ/TC)	
	INPUT	OUTPUT
Agriculture	201.80	
Industry	49.40	
Ethanol produced		1921.30
Bagasse surplus		168.7
TOTAL (external flows)	**251.20**	**2090.00**
Output/Input	8.3	

sugarcane processed could generate 100-200 kwh of electric energy (Neto, 2000). All the factory's power needed in the Brazilian sugar mills today is supplied by using bagasse and the energy surplus gets sold to the local electric companies (Alcoolbras, 2005-b). The third contribution is through production of biodiesel. Ethanol from sugarcane is a component used during the processing of biodiesel in Brazil. This renewable energy product can be obtained by means of chemical reactions of ethanol with vegetable oil extracted from soybeans, peanuts, sunflowers, etc. which are widely used as rotation crops in a sugarcane field (Mesquita *et al.*, 2004). Throughout the process of ethanol production using sugarcane, practically nothing is wasted. Molasses are used for fermentation. Bagasse is used to produce all of the factory's power. Vinasse is used as a field fertilizer. Using bagasse as a cellulose source can also produce ethanol which is said to give another 90% increase of ethanol using the same tonnage of raw material. The trash such as sugarcane leaves left in the field during harvesting is projected to substitute bagasse as the fuel power source.

Sugarcane has been shown to be the cheapest raw material for biofuel production. It is completely different from petroleum since it is a renewable resource. Its product, ethanol, is definitely the most energy efficient liquid fuel alternative to petroleum oil for tropical countries (Dharmawardene, 2005 a, b).

Why Brazil?

Two factors have made the sugarcane agro industry in Brazil become a world reference for excellence. Firstly, it has the world's lowest production cost and secondly, it is the only country among the big producers that is still expanding (Ethanol Guide, 2005). Brazil is able to easily double its production due to the vast land area that it possesses and also due to the excellent climate conditions the country enjoys. Currently, 60,000 producers cultivate sugarcane in Brazil in an area which has reached approximately 6 million hectares (Table 3). About 50% of the processed cane is destined to ethanol production and the other 50% to sugar production. Nevertheless, there still remains the possibility of using part of the 90 million hectares of the center-east thick vegetation area called cerrado without cutting down a single tree in the Amazon forest. The production flexibility and the investment capacity for a renewable energy are guaranteed by approximately 324 private factories which produce ethanol and sugar in Brazil (Ethanol Guide, 2005).

Brazil used to be one of the most dependent countries on oil imports. In the 1970s, when the oil crisis occurred, the Brazilian government decided to stimulate ethanol production from sugarcane with the Proalcool program. In May 1979, Brazil released its first national car powered completely by hydrous ethanol fuel (O Estado de Sao Paulo -Especial, 2005). By law, the common gasoline is also mixed with 20-25% anhydrous ethanol. It is estimated that more than 80% of the whole country's car fleet in 2005 were powered either by alcohol or by a bi-combustive motor which can use both alcohol and gasoline. Today, Brazil has practically become economically independent of imported oil. With improvement of the distillery technology, ethanol fuel has become so cheap that it costs 50% less than oil based fuel prices. Vast land, good soil, suitable climate, excellent sugarcane varieties, improved technology on both field production and fermentation process were all the factors Brazil needed to implement a successful energy efficient sugar and alcohol production systems. In

Table 3. Agriculture area used by soybean, corn and sugarcane (Ethanol Guide, 2005)

ITEM	Million ha	% of Brazil's total
Brazil's total area	851	100
Agriculture and pasture land	297	35
Soybean	21	2.5
Corn	12	1.4
Sugarcane	5.4*	0.6
Other crops	21.6	2.5

*Census made by Conab in 2006 indicates 5.92 million ha as sugarcane cultivation area.

addition, this success allows Brazil to make the cheapest sugar and ethanol in the world. With 16 billion liters of ethanol produced in 2005, Brazil is now constructing another 40 new

factories which will produce 25 billion liters within 3 years to attend not only the internal need but also catching up to the world's increasing market demands (Table 4) (O Estado de Sao Paulo, 2005). In addition, Brazil is now initiating programs to replace diesel fuel with ethanol mixed with vegetable oils. This biodiesel program in turn will push for more sugarcane and alcohol production (O Estado de Sao Paulo - Agricola, 2005).

A Total Integration System of Alcohol-Biodiesel

For the last 30 years, Brazil has developed a very efficient system for using alcohol as a renewable fuel. It is quite logical that, with the governmental stimulation of biodiesel program, the sugar and alcohol industry in Brazil starts to study the possibility of transforming their factories of sugar and alcohol into units of energy production, fuel and foods by means of integration into the productive chains of cereals and sugarcane (Alcoolbras, 2005 a). The project predicts a unification of 2 important production potentials of Brazil, cereals and alcohol, to offer to the world a solution of biofuel with maximum competitiveness. Since today those factories already produce alcohol and energy, it is a natural evolution that they also produce biodiesel which needs these two components during its process (Alcoolbras, 2005 a). Besides, the main component, oil from oil plants, will not experience a shortage. In Brazil,

Table 4. Alcohol market – Estimated alcohol demand for 2010

Country	Billion liters
Brazil	> 16.9
USA	18-20
Japan	6-12
Europe	9-14

20% of the total sugarcane areas are also used to produce oil plants like soybeans because of the crops rotation process that is practiced. The system can be interpreted as in Fig. 1.

The sugar and alcohol industry will build a biodiesel producing unit that includes an oil processing factory since

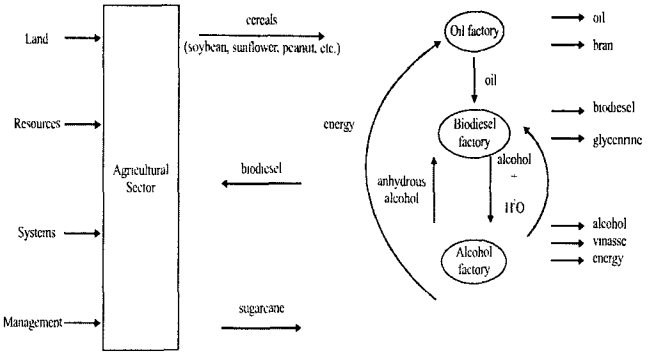

Fig. 1. A total integration system of alcohol-biodiesel (Alcoolbras, 2005 a)

they already have all the raw materials needed for production including the costlier energy. This way, the sugar and alcohol industry here will become production units which will produce both energy and foods. Another by-product of this chain is glycerine which can be sold to pharmacy and cosmetic industries (Alcoolbras, 2005 a).

This project is not just a dream. Dedini S/A, a Brazilian leader in supplying to sugar and ethanol factories, already has built a biodiesel factory to showcase this idea and Dedini supplies the necessary equipment to biodiesel factories that produce up to 40 million liters per year. Brazil today consumes about 38 billion liters of diesel per year. The demand will initially be 720 million liters in 2006 with 2% mixture of biodiesel to oil diesel. It is estimated that by 2020, the mixture will be at least 20% which will create a demand of approximately 13 billion liters per year (Alcoolbras, 2005 a). With a great diversity of ecosystem in Brazil, the country permits the utilization of many types of oil crops to produce this liquid biofuel (Table 5). Brazil does have the conditions to become one of the biggest biodiesel producers of the world.

It is believed that in the near future, the worldwide energy market could be even bigger than the food market. Brazil, with its tremendous resources and excellent technology in alcohol and biodiesel, could supply 60% of the world's need within 30

Table 5. Characteristics of some oil crops in Brazil with energy use potentials

Species	Production (t/ha)	% Oil	Life Cycle	Production Regions	Harvest	Oil Production (T/ha)
Soybean	2-3	17	Annual	All regions	Mechanized	0.2-0.4
Sunflower	1.5-2.0	38-48	Annual	Center-South	Mechanized	0.5-0.9
Castor bean	0.5-1.5	43-45	Annual	Northeast	Labored	0.5-1.2
Oil Palm	15-25	20	Perennial	North	Labored	3-6
Cotton	0.8-1.4	15	Annual	North, Northeast, Center-South, Center-East	Mechanized	0.1-0.3
Peanut	1.5-2.0	40-43	Annual	Center-South	Mechanized	0.6-0.8
Physic nuts	2-12	35-40	Perennial	North, Northeast, Center-South, Center-East	Labored	1-5

Source: Meirelles (2003)

years (O Estado de Sao Paulo - Agricola, 2005). This is very important since this energy provided will be a cheap, clean and renewable energy.

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