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ROUNDTABLE: SUCCESSES WITH BIOENERGY

The Brazilian Experience

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THE BRAZILIAN EXPERIENCE

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1. INTRODUCTION

A large territory, excellent agricultural areas associated to geographical location and climate give to Brazil a privileged position as a world biomass producer. One important aspect for such comparative advantage is the fact that Brazil is a country plenty of sun.

Sun radiations, incident over the earth, result in other different forms of energy sources, either to be used directly in thermo-solar collectors and in photovoltaic cells, or to be used indirectly through intervention over another natural phenomena induced by solar energy, such as, wind, water cycle and photosynthesis. All these sources are of renewable energies.

The total amount of solar energy, incident over the earth is of the order of 1.5×10^{18} kWh / year, from which 0.02% or 3.04×10^{14} kWh / year are stored in the plants by means of photosynthesis. Such stored amount of energy is equivalent to almost 10 times the world consumption, which is 0.35×10^{14} kWh / year, summing up all sources.

Photosynthesis is the synthesis of carbohydrate, and other organic compounds of high energy content, from substances of low energetic potential existent in the atmosphere, like carbon dioxide and water. It can be represented by the following reaction, where $\lambda\nu$ is the energy of photons:

$$6CO_2 + 12H_2O + \lambda\nu \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$$

The main organic compounds synthesized in plants are essentially glucyde ($C_6H_{12}O_6$) with heat power of the order of 3,600 kcal/kg (dry matter), stored basically in the form of natural polymers, like cellulose, hemi-cellulose and lignin. Therefore, in the process of photosynthesis, by means of chlorophyll, solar energy is stored in vegetal tissues (cellulose, glucyde, lipidium, protein, lignin, etc.) which, in last instance, is constituted by potential chemical energy.

The main factors which affect photosynthesis are solar radiation, temperature and water availability, besides nutrients. Biomass gross productivity varies considerably with the geographical latitude due to the associated solar energy availability and temperature. The highest biomass gross productivities vary from around 80 t / ha .year to 60 t / ha .year, and can be obtained in latitudes ranging from zero to 30. On the other hand, where average yearly temperatures are in the range of 18°C to 35°C, biomass gross productivities are the highest: above 20 t / ha . year. Also, average yearly precipitation from 1,500 to 3,000 mm/year gives the highest biomass gross productivities of 15 to more then 20 t / ha . year.

Photosynthesis produces organic matter as vegetables, such as: sugarcane, sorghum, soybean, castor oil plant, manioc, babassu palm, oil palm tree, eucalyptus, pinus, water hyacinth, water lily and others. From these plants it is possible to produce biofuels such as: ethanol, biodiesel, methanol from wood, charcoal, biogas and hydrogen.

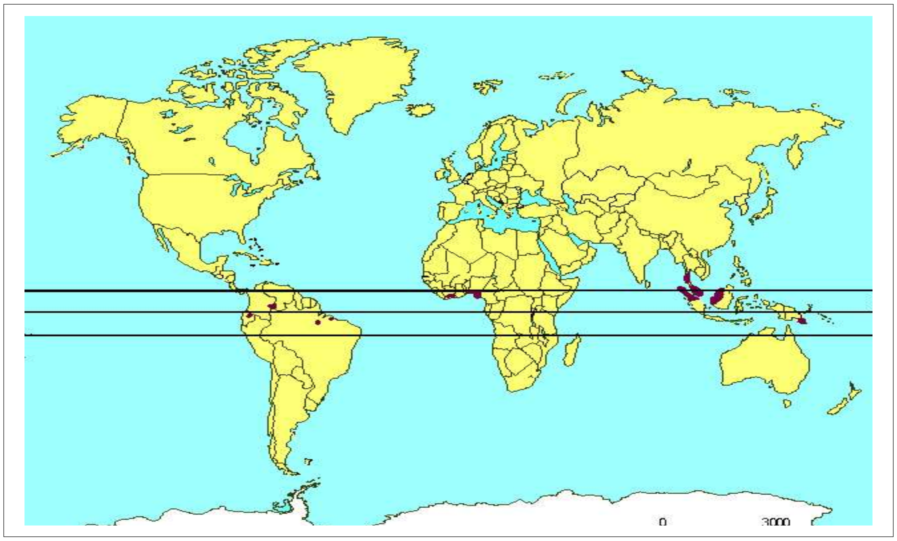
Different vegetal species can be converted into solid, liquid and gaseous fuels by means of different processes of conversion, economically adequate to each application, as exemplified in the following table.

Biomass or its derivative	**Process**	**Biofuel**
Sugar cane	Mechanical	Bagasse
Fermented of sugar cane, sorghum, etc.	Distillation	Ethanol
Eucaliptus and other forest species	Mechanical	Wood, chips, etc.
Vegetal oils	Transestherification	Biodiesel
Crop residues, urban residues, etc.	Anaerobic digestion	Methane
Water hyacinth, water lily, etc.	Anaerobic digestion	Methane
Crop residues and from wood industry	Pyrolysis and reform	Hydrogen
Ethanol	Direct reform	Hydrogen
Green algas	Bioconvertion	Hydrogen

Source: Reference 1

The geographical location of Brazil, its climatic conditions and large territory are well adequate for various species of plantations as sources of energy. Only few countries in the world have the same conditions to produce bioenergy.

Figure 1: Most Relevant Áreas of Palm oil Plantation and Production



Source: Agropalma/Oil World

The intent of the present contribution is to give a general view of some of the most relevant initiatives in Brazil in the direction of the production and use of different forms of bioenergy, from the government and from the private sectors.

2. Bioenergy Initiatives already Implemented in Brazil

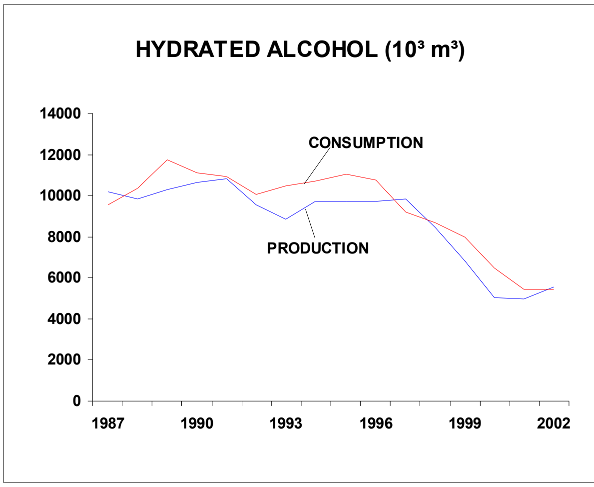
2.1. Ethanol

The PROALCOOL program was adopted in 1975 by the Brazilian government as a response to the international oil crisis. The objective of the program was to introduce a blend of gasoline with ethanol (gasohol), produced from sugarcane, to the Brazilian market and to incentive the development of pure ethanol fueled vehicles. Government measures of incentive included: a guarantee for ethanol fuel prices (maximum 65% of gasoline price); a 5% tax reduction for alcohol fueled vehicles, subsidized loans for ethanol producers to improve capacity; compulsory sales of ethanol at fuel stations and government control of fuel stocks to guarantee the supply and price.

Ethanol from sugarcane is nowadays used in Brazil in two ways: i) anhydrous alcohol as a gasoline additive for various types of vehicles (about 60% of the total) and ii) hydrated alcohol as the sole fuel in dedicated vehicles (about 40% of the total). A total of over 19 million vehicles are running today in the country, from which more than 16 million are gasohol and 3 million are pure ethanol driven cars.

The following figures give a view of the evolution of the production and consumption of anhydrous and hydrated alcohol in Brazil.

Source: National Energetic Balance BEN/MME



The production of sugarcane was 91 Mt, in 1975, yielding 6 Mt of sugar and 555,000 m^3 of ethanol; in 2002, sugarcane production reached 320 Mt, yielding 22.3 Mt of sugar and 12.6 M m^3 of ethanol.

After 30 years of the launching of the program, it is recognized that the Brazilian experience with bio-ethanol is a proof that economies of scale and technological advances can lead to increased competitiveness of renewable alternatives with respect to conventional fossil resources. It is also clear from such experience that adequate government incentives can lead to positive environmental, economical as well as social development in emerging economies. From 1980 to 2002, price reduction obtained was in the order of 71%. As the efficiency and cost competitiveness of ethanol production evolved over time, this support was no longer needed and was not applied.

It is important to register that, the total amount of investments in the agricultural and industrial sectors for the production of ethanol for automotive use, in the period 1975-1989, reached a total of US$ 4.92 billion (2001US$) directly invested in the program. On the other hand, savings with foregone imports evaluated at international prices, have amounted to US$ 52.19 billion (2003 US$) from 1975 to 2002.

In the Brazilian market of light vehicles the local manufacturers sold, from 1979 to 2002, 5,505,214 units (25.2%) alcohol powered and 16,305,554 units (74.8%) fueled with gasoline (this meaning, gasohol, with 19 to 26% alcohol added to pure gasoline). Presently, there are no subsidies for anhydrous or hydrated ethanol production. Hydrated ethanol is sold for 60-70% of the price of gasohol at the pump, due to significant reductions in production costs. We believe that the economic competitiveness of ethanol with respect to gasoline in Brazil has been a reality for several years already and will continue for several years to come, especially with the current increase of the crude oil in the world market.

2.2. Flex-fuel Vehicles

Flex-fuel vehicles were introduced in the Brazilian market, in 2003, and can be considered a fortunate consequence of the PROALCOOL program. The introduction of this new transport technology was a decision of the Brazilian automobile industry.

Flex-fuel vehicles are equipped with dual fuel engines, powered with gasoline and/or alcohol, giving the consumer total freedom to choose one of the fuels, or mixing them in any proportion. The consumer now is able to choose the fuel having the lower price or better performance. It should be reminded that standard gasoline in Brazil is sold with around 22% of alcohol added.

In 2004, 19 different models of cars were introduced in the Brazilian market, representing 30% of car sales in the country during that year or 600,000 units. It is expectation of the manufacturers that, by the end of 2007, 67% of the overall car sales will be equipped with Flex-fuel technology.

2.3. PROINFA (Biomass for generation of electricity)

The *Program of Incentive to Alternative Sources of Electrical Energy* – PROINFA was created by the Brazilian government in 2002, with the aim of increasing the participation, in the national interconnected system, of electrical energy based on wind, small hydropower – PCH and biomass.

The long term goal of PROINFA is to increase the contribution of the new renewable energies (wind, PCH and biomass) which, at present, is less than 4%, to 10% of the electricity supply for the next 20 years.

In the first phase of the Program, ELETROBRÁS the state owned electrical holding company, is obliged to sign purchase power agreements for 20 years with independent producers whose projects have been approved. Projects totaling 1,100 MW of biomass power plants will be contracted for starting operations until the 31st of December, 2006. Prices of energy to be paid by ELETROBRÁS will be subsidized, in order to make them attractive to the entrepreneurs. The private investments will be in the order of US$ 3 billions which, as estimated, should generate 150 thousand direct and indirect job placements during the construction and operation.

In the first phase, 48 projects for power plants construction using biomass for electricity generation will be constructed under PROINFA, totaling 1,100 MW – being 508.78 in the state of São Paulo, 203 MW in the state of Paraná, 85.62 MW in Goiás , 63.2 MW in Pernambuco and 60.5 MW in the state of Espirito Santo. Most of the approved projects in this phase are for plants using sugarcane bagasse, but other biomass is being used such as wood residue, rice straw.

The second phase of the Program will possibly be launched in 2006, but this may be postponed for a later date.

3. The Biodiesel Program

Although the Brazilian energy matrix is relatively clean when compared to the rest of the world (44% of the supply offer is from renewable sources, against 14% in the world) the design of the energy policy of Brazil takes more and more into account the world’s concern with the global climate changes and the search for diversification of the national energy matrix.

Transports in Brazil are largely based on mineral diesel powered trucks and busses. The total Brazilian consumption of diesel oil in 2003 was 38 billion of liters, from which 29 billion were used for transports and 5 billion in the agricultural and cattle activities.

As the world leader in the production and use of ethanol fuel, Brazil is confident to reach the same success with the production and utilization of biodiesel. As was mentioned before, Brazil has an almost unique conjunction of factors – geographical location, climate conditions and vast territory which is adequate to plantations various species , and therefore is ready to give a positive response to this new challenge.

In addition to looking for a cleaner matrix and self-sufficiency in fuel supply, the intent of the Brazilian policy for biodiesel is to direct part of the production to rural communities, then permitting small producers to make use of their own Biodiesel and to increase their income. If ideally it were possible to convert the present entire demand of mineral oil supply of 38 billion liters, as indicated above, this would mean a potential of achieving 5.2 million job-placements and 60 million of hectares planted, according to the federal agricultural research institute EMBRAPA . Also, according to the Official Census, Brazil has 100 million hectares of unproductive land and 4.6 million families without access to the land. Therefore, this program will have a very positive impact on reducing rural poverty.

Figure 2: Castor Oil Plant

Figure 3: Macaúba Nuts

Figura 4: Palm Oil Nuts

Figura 5: Babassu Nut Cluster

Vegetal oils can be produced in Brazil from several plant species with different indexes of productivity, as given in the following indicative figures:

castor oil:	1.200 l/ha/yr.
babaçu:	1.600 l/ha/yr.
palm oil:	5.950 l/ha/yr.
macaúba:	4.000 l/ha/yr.

3.1. Recent government and private outcomes

Since January 2005, Law nr. 11,097 entered into effect authorizing the introduction of biodiesel in the Brazilian energy matrix. The Law permits that, for the next three years, the addition of 2% of biodiesel (B2) to the petroleum diesel. This percent value will became mandatory after 1st of January,2008. After 2013, the mandatory value of addition will increase to 5% (B5). If local production of biodiesel, meant to cope with national demand permits, the time schedule of mandatory implementation can be reduced.

The addition of 2% of biodiesel to the mineral diesel will open a potential Brazilian internal market for the next three years of at least 800 million liters per year for the new fuel.

The official investment bank BNDES opened a special line of financing to support projects of biodiesel. It is now possible to finance up to 80 to 90% of a project, covering all phases of production from plantation to purchasing machineries and equipments.

In April, 2005 the first industrial plant of biodiesel was inaugurated in Cassia, state of Minas Gerais, which belongs to the private company Soyminas (Biobras Group). The unit will produce biodiesel from sunflower and wild radish and has an installed capacity of 12 million liters per year.The plantation to supply this first industrial plant was the in charge of 200 family farmers. At the same time, the filling of the vehicle tank with the new biodiesel (2% addition) is already possible in some few gas stations.

A second industrial biodiesel plant was also inaugurated in April, 2005, owned by the private group Agropalma, with installed capacity of 8 million liters per year. In this plant, biodiesel is produced by using residues of palm oil as raw material. The company has 32,000 hectares of palm oil tree plantations. This project is a good example of the economy/ecology integration. It encompasses a total area of 82.000 hectares, where 50.000 are environmental preservation areas, maintaining the original vegetation cover and where hunting and fishing are prohibited as a commitment to keep the ecosystem unchanged. During implementation of new plantation areas, priority is given to degraded areas to be recovered by palm trees. Gallery forests, which protect water courses, have been preserved in its totality. For future projects of new areas implantation, it will be mandatory the use of degraded areas.

Advanced experiments are being made by university groups with the support of car companies A first commercial vehicle fleet is running on 30% biodiesel (B30). Currently, new engines running with B100 are under development. In this context, it is necessary to develop new sealing materials and injection pumps that can resist pure biodiesel utilization. The major diesel engine producers of Latin America are also interested in developing new biodiesel engines.

3.2. Opportunities

As mentioned before, the addition of biodiesel will be mandatory in Brazil (2% after 2008 and 5% after 2013). This will open excellent investment opportunities in the production of the new fuel.

Considering that the Amazon Ecosystem is ideal for plantation of the best species for vegetal oil production, a small deforested area of the Amazon Region could be used with guarantee of purchase of the vegetal oil as an energy alternative. Mainly it could bring a solid way to refrain deforestation of the Region.

Social, economic and environmental stability of the Amazon would be achieved through a program to be implemented in areas already deforested which are concentrated in the so called deforestation arc (or arc of fire), indicated in the following map.

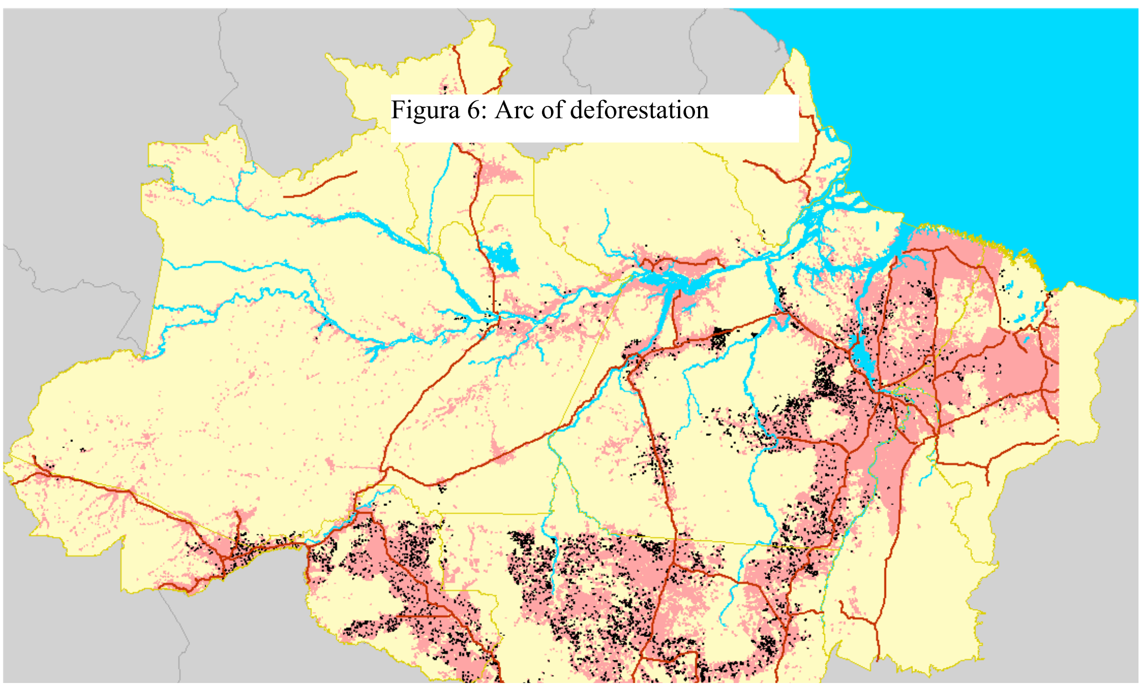


Figura 6: Arc of deforestation

4. THE FUTURE WITH HYDROGEN

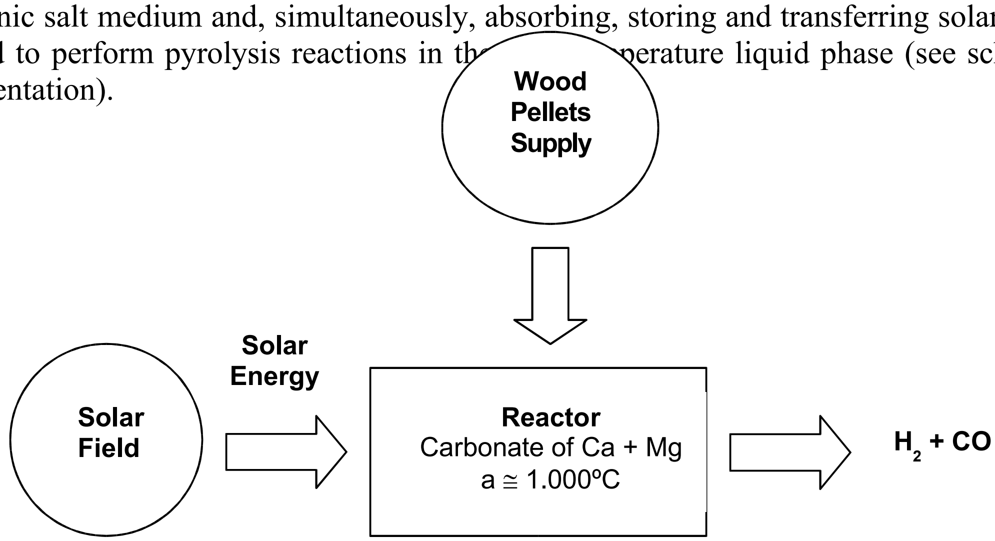
As mentioned in the introduction, hydrogen in one of biofuels that can be obtained from crop residues and from wood industry, by means of a process of pyrolysis and reform, or via ethanol by process of direct reform.

Several countries are looking to the future and preparing themselves for a time of shortage or without petroleum at all in a defensive attitude against the uncertainties of the world market. Hydrogen is one of the possibilities to replace, in part, the energy demand that today is attended by petroleum and its derivatives. Some are already talking about a new era: the economy of hydrogen.

4.1. Solar Gasification of Biomass

A new solar process and reactor for thermo-chemical convertion of biomass into synthesis gas is under development at the Weizmann Institute of Science, with which FBDS has a very close collaboration.

The concept of the new process is based on dispersion of biomass particles in a molten inorganic salt medium and, simultaneously, absorbing, storing and transferring solar energy needed to perform pyrolysis reactions in th[illegible]perature liquid phase (see schematic representation).



A lab-scale reactor filled with carbonates of potassium and sodium was set up to study the kinectics of fast pyrolysis and the characteristics of transient heat transfer for cellulose particles (few millimeters size) introduced into the molten salt medium. The operating conditions were reaction temperatures of 800-915 °C and a particle peak-heating rate of 173 °C/sec. The assessments performed for a commercial–scale solar reactor demonstrated that pyrolysis of biomass particles dispersed in a molten salt phase could be a feasible option for the continuous round-the-clock production of hydrogen using solar energy only.

Presently, the Weizmann Institute is assessing the technical and economic feasibility of a in commercial scale reactor that could be built and operated in Brazil, using eucalyptus pellets from the Brazilian planted forest.

4.1. Fuel-cells using Ethanol

Fuel-cells are electrochemical devices that convert chemical energy of a fuel in electricity, directly, through reactions of oxidation and reform, that is, without combustion. The most used fuel in fuel-cells is hydrogen and the oxidant is the oxygen air.

Ethanol obtained from sugarcane, as referred earlier, is one of the most important energy carriers produced and used in Brazil. Ethanol is used in Brazilian vehicles blended at the proportion of 22% to the gasoline or even 100% pure. Ethanol has great advantages as it is obtained from biomass and, therefore, is renewable.

Fuel-cells with direct ethanol is under development in Brazil, a joint effort of federal government and private companies. These types of cells are suitable for application in transports and portable devices.

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