The Brazilian Biofuels Experience

Flavio Castelar
Executive Director – APLA Brasil

GBEP – Bioenergy Week
Mozambique
Ethanol

The future of fuel?

Henry Ford - 1906

Henry Ford blend Ethanol and Gasoline to start up the first T model.
Age of Renewable Fuels

2014
Brazilian Sugarcane Industry - Development cycles

1502
Agricultural Cultivation Cycle of Sugar Cane Production

- Artesian Mills
- Mills
- Mills Sugar + Ethanol
- Proalcool

2005
Expansion cycle – sugarcane industry: ethanol + bioelectricity + sugar +..

- Bioenergy + Sugar + Investment Funds + Ethanol + CO2 Bioelectricity
- Bioenergy + Investment Funds + Sugar + Ethanol + Tradings + Bioelectricity + CO2
- Bioenergy + Investment Funds + Sugar + Ethanol + Bioelectricity + Bioelectricity + Tradings + CO2 + Biochemical + Bioplastics

Future business of Sugarcane biomass: The sustainable supply of bioenergy and food with lower CO2

Global Player de Alimentos, Bioenergía & Sugar – Ethanol – Bioelectricity – CO2 – Bioplastics + Biochemical + etc..
The Brazilian Ethanol Program Pro Alcohol

Adopted in 1975 due to the international petrol crisis:

1. Adding ethanol to gasoline
2. Incentive for development of vehicles 100% on ethanol

Why Ethanol?

- Brazil has been one of the main producers of sugar cane since century XVI.
- Since 1930 (especially during the 2nd World War) ethanol mixed with gasoline has been used as automotive fuel in Brazil with good results.
Reasons to produce Ethanol

a) High costs of petrol production

b) The rural development opportunities: The production of raw material allow a new and rentable utilities to the land, that's propose new economical opportunities to rural communities.

c) Biofuels represents an opportunity to develop new export markets for countries with favorable trade and tariff conditions.
Production Costs – Ethanol & Gasoline

- Sugarcane (Brasil): US$/Ton (F.O. Litch's)
- Corn (USA)
- Wheat
- Gasoline

Conclusions
Production of Ethanol per unit area

1000 liters per hectare

- Sugarcane Brasil
- Beet E.U.
- Sugarcane India
- Corn USA
- Cassava Thailand
- Wheat E.U.

International Energy Agency, MTEC & UNICA
Reasons to Produce Ethanol

Reducing emissions when using ethanol

- Grain Ethanol (USA/EU)
- Beet Ethanol (EU)
- Sugar Ethanol (Brasil)

International Energy Agency (IEA)
Flex Fuel Market

[Bar chart showing Flex Fuel Market percentages from 2003 to 2012]
Sugarcane Sector

Harvest 12/13

588 million sugarcane tons = 705 million Oil Barrel per year

1.9 Million Oil Barrel per Day
Harvest 2013/2014 - Brasil

- **8.583.073** – Sugarcane Hectares
- Average Productive: **75 ton/ha**
- Avg. TRS: **132 kg/t**

- Sugarcane production: **651.523.817** tons
- Sugar production: **37.548.816** tons
- Sugarcane to produce sugar: **296.834.251** tons
- % of Sugarcane to produce Sugar: **45,56%**

- Ethanol Production: **27.495.139 m³**
- Anhydrous Ethanol: **12.113.129 m³**
- Hydrous Ethanol: **15.382.008 m³**
- Sugarcane to produce Ethanol: **354.689.565** tons
- % of Sugarcane to produce Ethanol: **54,44%**

Fonte: DATAGRO
The Brazilian Land Utilization

en millones de hectáreas*

<table>
<thead>
<tr>
<th>Área total</th>
<th>Vegetación natival</th>
<th>Tierras para cultivo</th>
<th>Otros</th>
</tr>
</thead>
<tbody>
<tr>
<td>851</td>
<td>498</td>
<td>338</td>
<td>15</td>
</tr>
<tr>
<td>100%</td>
<td>58%</td>
<td>40%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Disponible 30%

103

Pasto

172

51%

Agricultura

55

16%

Caña de azúcar

8,7

2,6%

Litros de etanol por hectárea

Años 70 | Hoy | Futuro

*Área para el año de 2009.

Fuente: ICONIE, ESALQ y IBGE.
Elaboración: COSAN, UNICA y APLA.
Sugarmills in Brazil

<table>
<thead>
<tr>
<th>States</th>
<th>Sugarmill</th>
</tr>
</thead>
<tbody>
<tr>
<td>São Paulo</td>
<td>202</td>
</tr>
<tr>
<td>Paraná</td>
<td>32</td>
</tr>
<tr>
<td>Minas Gerais</td>
<td>40</td>
</tr>
<tr>
<td>Mato G. do Sul</td>
<td>21</td>
</tr>
<tr>
<td>Goiás</td>
<td>33</td>
</tr>
<tr>
<td>Mato Grosso</td>
<td>10</td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td>8</td>
</tr>
<tr>
<td>R. Grande do Sul</td>
<td>2</td>
</tr>
<tr>
<td>Espírito Santo</td>
<td>6</td>
</tr>
<tr>
<td><strong>Centro-Sul</strong></td>
<td><strong>354</strong></td>
</tr>
<tr>
<td>Alagoas</td>
<td>24</td>
</tr>
<tr>
<td>Pernambuco</td>
<td>24</td>
</tr>
<tr>
<td>Paraíba</td>
<td>9</td>
</tr>
<tr>
<td>R. Grande do Norte</td>
<td>4</td>
</tr>
<tr>
<td>Bahia</td>
<td>4</td>
</tr>
<tr>
<td>Maranhão</td>
<td>4</td>
</tr>
<tr>
<td>Piauí</td>
<td>1</td>
</tr>
<tr>
<td>Sergipe</td>
<td>6</td>
</tr>
<tr>
<td>Ceará</td>
<td>3</td>
</tr>
<tr>
<td>Amazonas</td>
<td>1</td>
</tr>
<tr>
<td>Tocantins</td>
<td>1</td>
</tr>
<tr>
<td>Pará</td>
<td>1</td>
</tr>
<tr>
<td>Rondônia</td>
<td>1</td>
</tr>
<tr>
<td><strong>Norte-Nordeste</strong></td>
<td><strong>83</strong></td>
</tr>
<tr>
<td><strong>Brasil</strong></td>
<td><strong>437</strong></td>
</tr>
</tbody>
</table>

Sugarmill (Ethanol and Sugar) 253
Sugarmill (Sugar) 16
Sugarmill (Ethanol) 168
## Conclusions

### RESULTS OF INDUSTRIAL TECHNOLOGICAL EVOLUTION IN THE SUGAR & BIOETHANOL SECTOR – 2007

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2014</th>
<th>Today</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRUSHING CAPACITY (TCD) - 6X78”</td>
<td>5,500</td>
<td>14,000</td>
</tr>
<tr>
<td>FERMENTATION TIME (H)</td>
<td>24</td>
<td>6 - 8</td>
</tr>
<tr>
<td>BEER ETHANOL CONTENT (°GL)</td>
<td>6.5</td>
<td>&gt; 9.0</td>
</tr>
<tr>
<td>EXTRACTION YIELD (%SUGAR) - 6 MILL UNITS</td>
<td>93</td>
<td>98</td>
</tr>
<tr>
<td>FERMENTATION YIELD (%)</td>
<td>80</td>
<td>92</td>
</tr>
<tr>
<td>DISTILLATION YIELD (%)</td>
<td>98</td>
<td>99.7</td>
</tr>
<tr>
<td>TOTAL YIELD (LITER HYDR. BIOETH./TON CANE)</td>
<td>66</td>
<td>87</td>
</tr>
<tr>
<td>TOTAL STEAM CONSUMP. (KG Steam/T CANE)</td>
<td>600</td>
<td>320</td>
</tr>
<tr>
<td>STEAM CONSUMPTION - HYDR. (KG S/LITER)</td>
<td>3.4</td>
<td>1.6</td>
</tr>
<tr>
<td>STEAM CONSUMP. - ANHYDR. (KG S/LITER)</td>
<td>4.5</td>
<td>2.0</td>
</tr>
<tr>
<td>BOILER – EFFICIENCY (% LHV)</td>
<td>66</td>
<td>89</td>
</tr>
<tr>
<td>PRESSURE (BAR) / TEMPERATURE (°C)</td>
<td>21 / 300</td>
<td>120/ 540</td>
</tr>
<tr>
<td>SURPLUS BAGASSE (%) - BIOETHANOL MILL</td>
<td>UP TO 8</td>
<td>UP TO 78</td>
</tr>
<tr>
<td>BIOMETHANE FROM STILLAGE (NM³/LITER BIOETH.)</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>STILLAGE PRODUCTION (L STILLAGE/L BIOET)</td>
<td>13</td>
<td>0.8</td>
</tr>
</tbody>
</table>

### PRESSURE (BAR) / TEMPERATURE (°C)

- **2014**: 21 / 300
- **Today**: 120/ 540
BIOETHANOL + BIOELECTRICITY + BIODIESEL INTEGRATION
FIRST GENERATION 3 BIOS MILL

Biodiesel Plant integrated to Barralcool Mill

Barralcool Mill

Sugarcane Land / Renovation

DEDINI: INTRODUCTION OF THE CONCEPT TO THE WORLD MARKET AND FIRST WORLD SUPPLY/ 1st WORLD CONTINUOUS ETHYLIC PROCESS PLANT

BARRALCOOL MILL: 1st MILL IN THE WORLD PRODUCING THE 3 BIOS: BIOETHANOL, BIOELECTRICITY AND BIODIESEL
Brazilian Electricity Capacity

![Graph showing Brazilian electricity capacity]

- **Itaipu** (9,699 MWe)
- **Angra 2** (1,260 MWe)
- **Madeira (Santo Antônio)** (2,000 MWe)

**Years:**
- 2006/07
- 2007/08
- 2008/09
- 2009/10
- 2010/11
- 2011/12
- 2012/13

**Energy Sources:**
- bagaço (75%)
- bagaço (75%) + palha (50%)
• The Brazil total sugarcane cogeneration capacity is 7,914 MW

• 100% of Brazil’s sugar and ethanol factories are self-sufficient in electricity.

• Research shows that Brazil’s installed bioelectricity capacity could reach 10,000 MW by 2016.

• Brazil has world-class expertise in the technology and construction of ethanol plants that generate electricity by burning sugarcane bagasse.
Full Cogeneration Capacity - Brazil

<table>
<thead>
<tr>
<th>COMBUSTÍVEL</th>
<th>POTÊNCIA TOTAL EM MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOMASSA DE CANA</td>
<td>7.917</td>
</tr>
<tr>
<td>GÁS NATURAL</td>
<td>1.340</td>
</tr>
<tr>
<td>LICOR NEGRO</td>
<td>743</td>
</tr>
<tr>
<td>ÓLEO COMBUSTÍVEL</td>
<td>227</td>
</tr>
<tr>
<td>GÁS DE ALTO FORNO</td>
<td>412</td>
</tr>
<tr>
<td>GÁS DE PROCESSO</td>
<td>408</td>
</tr>
<tr>
<td>OUTROS</td>
<td>152</td>
</tr>
</tbody>
</table>

### Bioenergy – Sugarcane Biomass

<table>
<thead>
<tr>
<th>Estado</th>
<th>Nº de Unidades de Cogeração</th>
<th>Potência Total em MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAO PAULO</td>
<td>422</td>
<td>4.521,31</td>
</tr>
<tr>
<td>MINAS GERAIS</td>
<td>55</td>
<td>896,71</td>
</tr>
<tr>
<td>MATO GROSSO DO SUL</td>
<td>33</td>
<td>789,75</td>
</tr>
<tr>
<td>GOIAS</td>
<td>39</td>
<td>656,22</td>
</tr>
<tr>
<td>PARANA</td>
<td>40</td>
<td>262,92</td>
</tr>
<tr>
<td>ALAGOAS</td>
<td>49</td>
<td>230,36</td>
</tr>
<tr>
<td>PERNAMBUCO</td>
<td>40</td>
<td>180,82</td>
</tr>
<tr>
<td>PARAIBA</td>
<td>11</td>
<td>80,20</td>
</tr>
<tr>
<td>MATO GROSSO</td>
<td>16</td>
<td>68,83</td>
</tr>
<tr>
<td>SERGIPE</td>
<td>8</td>
<td>58,20</td>
</tr>
<tr>
<td>RIO GRANDE DO NORTE</td>
<td>9</td>
<td>57,00</td>
</tr>
<tr>
<td>RIO DE JANEIRO</td>
<td>2</td>
<td>44,00</td>
</tr>
<tr>
<td>PARA</td>
<td>1</td>
<td>25,00</td>
</tr>
<tr>
<td>ESPÍRITO SANTO</td>
<td>9</td>
<td>23,10</td>
</tr>
<tr>
<td>BAHIA</td>
<td>4</td>
<td>14,00</td>
</tr>
<tr>
<td>PIAUI</td>
<td>4</td>
<td>8,80</td>
</tr>
</tbody>
</table>

Fonte: datacogen.com.br
Energy Supply Structure

Brazil Energy Matrix in 2012

Utilities del Ethanol

Buses powered 100% by Ethanol

Bioplastics (Bio ethylene)

Biodiesel Production (transesterification)

Small Planes 100% powered with ethanol, Planes to agriculture

Flex-Fuel Motorcycles (gasoline/ethanol)

Tractors powered by Diesel + Ethanol

Bio-hydrocarbons

Conclusions
March 2009, the market received 1st Flex Motorcycle, the CG 150 Titan Mix, in September 2009, another model was launched, NXR 150 Bros Mix, both from Honda. Nowadays we have more models.
The Brazilian Auto-Flex Market
16 producers and more than 100 models.
Green Plastic

Few advantages of green plastic:

• 100% renewable material
• It can also be recycled
• Reducing greenhouse gases
• Proposed sustainable development for the entire production chain

200,000 t of GREEN PE per year

200,000 t de PE VERDE por año

Corresponds to a reduction of 500,000 t* of CO₂ per year

equivale a una reducción de 500,000 t* de CO₂ por año

Which is equivalent to the emissions produced each year by 500,000 ** automobiles

equivale a la emisión de CO₂ de 500,000** automóviles por año

Which is equivalent to the CO₂ emissions produced each year from the energy consumed by 123,000 *** families

equivale a la emisión de CO₂ del consumo de energía de 123,000 familias por año
Green Plastic
Green Plastic
Conclusions
New sugar mill and distilleries plants will produce: sugar, ethanol, electric energy, biodiesel, sucrose byproducts and other carbon chain substances from sugarcane.

Future - new technologies: residues gasification, celluloses hydrolysis, optimization, industrial automation, fermentation process and yeast breeding, NFB, integrated production systems, precision agriculture, genetically modified sugarcane

Brazil is interested in establishing a global market for ethanol as a traded commodity.
Conclusions

✓ From 1975, when the Pro-Alcool was launched, the sugarcane utilization still are the biggest biomass applications in energy production in whole world.

✓ Almost 45% of energy and 19% of fuels in Brasil already are renewables. In the rest of the world, just 14% energy is renewable.

✓ Social Impact - More than 720,000 direct jobs and 200,000 indirect in agriculture land – decreasing of social ruptures and enviroalmental problems in the
100 countries could supply biofuels to 200 nations. Ethanol faces very high tariff and non-tariff barriers, while oil is traded almost freely. Nowadays just 20 countries can offer petrol to the world.
SUGARCANE!

To Eat  To Drive  To Fly  To Plug

For Business

photosynthesis

Sun  Water  Earth

Sugarcane

Sugar  Ethanol  Bioelectricity  Raw Material  CO2

Sugar  Food for people
Ethanol  Fuels with low CO2 emissions
Bioelectricity  Electricity with low CO2 emissions
Raw Material  Bioplastics, Biochemical and yeast
CO2  Reduction of GHG emission

Reduces Emision  To challenge  And to DRINK

CHEERS!
Arranjo Produtivo Local do Álcool
Ethanol Cluster
Arreglo Productivo Local del Alcohol