Learning from Brazil’s Experience in Ethanol – Emerging Trends and Technologies

Flavio Castellari – Executive Director
TECHNOLOGY AND PRODUCTION PROCESS

- **CANE**
  - Reception/Preparation
  - Extraction
  - Steam Generation (Boiler)
  - Electricity Generation (Turbogenerator)
  - Surplus Bagasse

- **SUGAR**
  - Sugar Process
  - Electricity Generation

- **MOLASSES**
  - Surplus Bagasse

- **JUICE**
  - Steam Generation (Boiler)

- **HIGH PRESSURE STEAM FLOW (DRIVING PURPOSE)**
- **LOW PRESSURE STEAM FLOW (THERMAL PURPOSE)**

- Other labels:
  - **BAGASSE**
  - **SURPLUS BAGASSE**
TECHNOLOGY AND PRODUCTION PROCESS

- CANE
- RECEPTION/PREPARATION
- EXTRACTION
- JUICE
- STEAM GENERATION (BOILER)
- SURPLUS BAGASSE
- ELECTRICITY GENERATION (TURBOGENERATOR)
- HIGH PRESSURE STEAM FLOW (DRIVING PURPOSE)
- LOW PRESSURE STEAM FLOW (THERMAL PURPOSE)
- SUGAR PROCESS
- SUGAR
- MOLASSES
- BIOETHANOL PROCESS
- BIOETHANOL
- STILLAGE
- BAGASSE
- JUICE
SUGAR MILL WITH ANNEX DISTILLERY
BEGINNING OF BRAZIL MODEL

TECHNOLOGY AND PRODUCTION PROCESS

CANE → RECEPTION/PREPARATION → EXTRACTION → JUICE → SUGAR PROCESS → SUGAR

JUICE → SURPLUS BAGASSE

ELECTRICITY GENERATION (TURBOGENERATOR)

STEAM GENERATION (BOILER)

BIOETHANOL PROCESS

STILLAGE

MOLASS

HIGH PRESSURE STEAM FLOW (DRIVING PURPOSE)

LOW PRESSURE STEAM FLOW (THERMAL PURPOSE)

SURPLUS BAGASSE

PROCESS

JUICE

SUGAR

STEAM

GENERATION

(BOILER)
TECHNOLOGY AND PRODUCTION PROCESS

CANE

RECEPTION/ PREPARATION

EXTRACTION

JUICE

SUGAR PROCESS

SUGAR

MOLASSES

BIOETHANOL

STILLAGE

BIOELECTRICITY

PRODUCT FLOW

HIGH PRESSURE STEAM FLOW (DRIVING PURPOSE)

LOW PRESSURE STEAM FLOW (THERMAL PURPOSE)

STEAM GENERATION (BOILER)

SUGAR PROCESS

BIOETHANOL PROCESS

ELECTRICITY GENERATION (TURBOGENERATION)

SURPLUS BAGASSE

BAGASSE
# Technological Evolution In The Sugar & Bioethanol Sector

<table>
<thead>
<tr>
<th>Metric</th>
<th>Beginning Proalcohol</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crushing Capacity (TCD) - 6x78&quot;</td>
<td>5,500</td>
<td>15,000</td>
</tr>
<tr>
<td>Fermentation Time (H)</td>
<td>24</td>
<td>6-8</td>
</tr>
<tr>
<td>Beer Ethanol Content (°GL)</td>
<td>7,5</td>
<td>&gt; 9,0</td>
</tr>
<tr>
<td>Extration 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 Consumption (Kg s/ton 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 Consumption - 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 Bioethanol)</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>
## Brasil Sugarcane Market

### 2017/18 crop
- **Sugarcane**: 633 millions of tons
- **Sugar**: 37 millions of tons
- **Ethanol**: 27 billion of liters

#### Sugarcane destination
- Ethanol 54%
- Sugar 46%

### 2018/19 crop
- **Sugarcane**: 620 millions of tons
- **Sugar**: 29 millions of tons
- **Ethanol**: 33 billions of liters

#### Sugarcane destination
- Ethanol 65%
- Sugar 35%

*Source: CONAB– Safra 2017/2018; Safra 2018/19*
Ethanol Production by hectares

Liters per Hectare

- Cane (Brazil)
- Beet (E.U.)
- Cane (India)
- Corn (USA)
- Cassava (Thailand)
- Wheat (E.U.)

SOURCE: IEA INTERNATIONAL ENERGY AGENCY 2008 /UNICA MTEC
Emission reduction when ethanol replaces gasoline

- Grains Ethanol (USA & E.U.)
- Beet Ethanol (E.U.)
- Sugarcane Ethanol (Brazil)

Emissions calculated by life-cycle basis - well-to-wheel
SOURCE: IEA INTERNATIONAL ENERGEY AGENCY 2004 (UNICA/APLA)
Employees

Sugarcane sector invests an average of **US$ 10,000/employment**

Brasil Sugarcane Map

Source: UNICA
ETHANOL
Why ethanol?
✓ Clean
✓ Renewable
✓ Low-carbon biofuel

The Ethanol can be used in two ways:
✓ Blended with gasoline E5 – E85 (anydrous)
✓ Pure ethanol E100 (hydrous)
Ethanol Benefits

✓ The rural development opportunities.
✓ Reduced Greenhouse emission.
✓ Better Performance.
✓ Lower Petroleum Usage.

Market Highlight

Ethanol already replaces around 40% of gasoline;

Source: ÚNICA & Nastari
Flex Fuel Engines Production

Source: ANFAVEA
GRAPHIC BY: APLA
Flex Fuel Producers in Brazil
**Prius Flex** - made by Toyota is the first Hybrid Flex car in the world. The Prius can run by three different fuels: ethanol, gasoline and energy.
e-Bio Fuel-CELL

Cruising range Of 600km-plus with 30 liters ethanol for zero-emission Bio-Ethanol Fuel-Cell model
Flex Motorcycles

2009 March, Honda launches the first flex motorcycle, the CG 150 TITAN MIX, and months later the second one, NX Bros Mix. At 2018 the CG160Flex debut it.
1/3 Sugarcane Juice
608x10^3 kcal

1/3 Bagasse 276 kg 50% of moisture
598x10^3 kcal

1/3 Straw 165 kg 15% of moisture
512x10^3 kcal

1.718x10^3 kcal

1 Oil Barrel = 1386x10^3 kcal
1 Sugarcane ton. = 1.2 Oil Barrel

Sugarcane Sector

Harvest 16/17

665 million sugarcane tons = 798 million Oil Barrel per year

2,1 Million Oil Barrel per Day

Source: Sugarcane energy potential (Oliverio 2003; Oliveiro and Ribeiro, 2006)
NEW TECHNOLOGY: Ethanol 2G

- Plants producing cellulosic ethanol in Brazil:
  - GranBio group
  - Raizen
  - São Manuel (CTC)

Brazil Actual Production Capacity (2016): 177 million litres.
COGENERATION
Bioelectricity
Bioelectricity from Sugarcane Bagasse Benefits in Brazil

✓ Low environmental impact
✓ Producers can obtain carbon credits
✓ Complementary to hydroelectricity
Bioelectricity: Sugarcane electricity exported to national grid

Source: ABRACEEL, CEISE Br, COGEN, UNICA. (2019).
Bioelectricity

21,5 thousands of GWh to the grid in 2018

Supply for 11,4 millions of households/year

Avoided the emission of 6,4 millions tons of CO2, equal to the work of 45 millions of native trees in 20 years

Source: ABRACEEL, CEISE Br, COGEN, UNICA. (2019).
Bioelectricity: Synergy between sugarcane electricity and energy stored.

- **GwH sold to the grid**
- **Level of stored energy in SE/CO reservoir (%)**

Source: UNICA (2019).
Bioelectricity

**BIOELECTRICITY USE**

*Brazilian potential to generate bioelectricity*

- **2023 (Bagasse and straw)**
- **2023 (Only bagasse)**

Sources: UNICA (2015) and EPE (2014)
BIOPLASTIC
Advantages of green plastic:

- Biodegradable plastics are renewable
- Good for the environment
- Require less energy to be produced
- Easier to recycle
- Not toxic
- Biodegradable plastics reduce dependence on foreign oil
Bioplastic

I’m green Plastic
Renewable source Carbon reduction
Braskem

CO₂

Sugarcane captures CO₂

MILL / Ethanol production / ETHANOL

Production of Green Ethylene and Green Polyethylene / GREEN PE

Reduction in greenhouse gases

Green Polyethylene is 100% recyclable

Consumers can opt for greener products

Green Polyethylene transformed into products

brasplast.com.br
Bioplastic
Where in the world is PlantBottle™ Packaging?

35+ Billion Bottles Worldwide
distributed across water, sparkling, juice and tea beverage brands

By 2020
PlantBottle™ Packaging
will be used for all new PET plastic bottles

As of June 3, 2015.
coca-colacompany.com/plantbottle

The Coca-Cola Company
in collaborations with our partners...
OTHER UTILITIES
• Embraer, General Electric (GE) and Amyris, together with Brazilian airline Azul staged the first-ever sugarcane fuelled jet flight just prior to the UN's Rio+20 Conference held in 2012.

• The innovative renewable jet fuel produced from Brazilian sugarcane reduces carbon dioxide emissions by 82%.

• Produced on an industrial scale, it has the potential to replace approximately 20% of the jet fuel produced from fossil fuels that are used annually by Brazil.
JetFuel
The airplane Ipanema (EMB 202³) uses just sugar cane ethanol to fly, in 2015 this airplane model has completed 10 years being sold in Brazil. The first airplane in the world certificated to fly with biofuel.
Ethanol Stove

Photo: Project Gaia

Photo: Cleancook
Ethanol Power Generator
Biodiesel

Sugarcane Diesel (B20) is used daily by approximately 400 public transit buses in Sao Paulo and Rio de Janeiro, the country’s largest cities. These buses have logged over 30 million kilometers with a blend of Amyris Renewable Diesel.
Utilities

- To Eat
- To Drive
- To Fly
- To Plug

For Business

- photosynthesis
- Sun
- Water
- Earth
- Sugarcane

- Sugar
- Ethanol
- Bioelectricity
- Raw Material
- CO2

- Food for people
- Fuels with low CO2 emissions
- Electricity with low CO2 emissions
- Bioplastics, Biochemical and yeast
- Reduction of GHG emission

Reduces Emision
To challenge
And to DRINK
CHEERS!

To Eat
To Drive
To Fly
To Plug

portalaplacom.br
apla.org.br
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.
Main World Ethanol Blends