Biobased development in Brazil – beyond ethanol

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Synthesis

• Apart from biofuels, biobased chemicals in Brazil are an agenda increasingly under consideration by government and policy agencies;

• No specific policy framework for a biobased economy (BBE) yet. But, PAISS is an example of a recent and successful financing program by BNDES/FINEP;

• Industry initiatives are becoming more diversified;

• Sugar based (1st and 2nd generation) biotech is becoming the dominant path;

• Most of the products are drop in.
OUTLINE

Beyond ethanol: BBE potential/challenges

1. Recent studies:
   - ABDI/CGEE: sectoral technology agenda
   - BNDES study: chemical industry diversification
   - BNDES/CTBE study: 2G ethanol dynamics

2. Policy initiatives

3. Industry initiatives
BBE is an emerging industry

The industry is under construction with 4 key co-evolving dimensions
1. Recent studies

ABDI/CGEE: sectoral technology agenda (2013/2014)

Driver

Innovation as a repositioning factor for national competitiveness

Goals

Improve industrial policies to foster innovation

Identify relevant technologies for sectoral competitiveness in the next 15 years

8 sectors selected → renewable chemicals
Methodology

Expert committee

85 emerging technologies

Respondent panel (industry, academy, government)

29 relevant technologies (26 priority and 3 critical)

Relevant technologies: high diffusion expected in Brazil in the next 15 years
Group 1: Raw materials development and production technologies (12)

Commodities
- Technological domain
- Large production scale
- Established logistics and commercialization

Sugarcane Soy

New crops
- Technological domain

Palm oil Castor oil

Microorganisms
- No technological domain

Jatropha Other palm trees

Technologies not only for genetic improvements using different techniques, but also concerning fertilizers and mechanized sowing and harvesting

EMBRAPA, 2012
Group 2: Biomass treatment technologies (6)

- Pre-treatment
- Enzimatic Hydrolysis
- Sugar
  - C5
  - C6
- Purification
- Glycerin
- Vinasse
- Treatment
Group 3: Conversion Technologies (8)

- Sugar
- Glycerin
- Ethanol
- Biotech (GMO)
- Chemical
- Substitute fossil based chemicals
Group 4: New products (6)

- Sugar
- Glycerin
- Biotech
- Chemical
- New products
BNDES study: chemical industry diversification (2014)

1. 19 sectors identified as opportunities for diversification
2. Renewable chemicals as a major source of innovative products and competitiveness
3. Potential and Challenges: strong feedstock position
In addition to being the most available culture, sugarcane is one of the most competitive feedstocks.

Note: The fermentable weight corresponds to carbohydrates that are consumed in the fermentation.

Source: Nexant (2013), Next Generation Biofeedstocks: Resources IS Renewables; Südzucker (2014); Bayer. Landesanstalt Für Landwirtschaft (2014)
SUGARCANE WASTE FEATURES ONE OF THE LOWEST PRODUCTION COSTS...

Cost to obtain the main agroindustrial residues
(US$/dry ton, 2013)

<table>
<thead>
<tr>
<th>Residue</th>
<th>Cost (US$/dry ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat Straw (USA)</td>
<td>116</td>
</tr>
<tr>
<td>Maize Straw (USA)</td>
<td>78</td>
</tr>
<tr>
<td>Cane Bagasse (Brazil)</td>
<td>59</td>
</tr>
<tr>
<td>Cane Straw (Brazil)</td>
<td>52</td>
</tr>
<tr>
<td>Rice Straw (Asia)</td>
<td>50</td>
</tr>
</tbody>
</table>

... AND THE LOWEST COST WHEN THE CONTENT OF FERMENTABLES IS CONSIDERED

Cost to obtain the main agroindustrial residues
(US$/fermentable ton, 2013)

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<tr>
<td>Rice Straw (Asia)</td>
<td>89</td>
</tr>
<tr>
<td>Cane Bagasse (Brazil)</td>
<td>88</td>
</tr>
<tr>
<td>Cane Straw (Brazil)</td>
<td>74</td>
</tr>
</tbody>
</table>

* Cost of bagasse considered as opportunity cost of input, which can be sold for the generation of electric energy

Note: The percentages of hemicellulose and cellulose of each residue were considered in the calculation of the cost per fermentable tone

Source: Nexant (2013), Next Generation Biofeedstocks: Resources IS Renewables; Kim & Day (2011); Franco, H. C. J. et. All (2013); North Central Sun Grant Center & South Dakota State University (2013); Iqbal ET al. (2013); Bain/Gas Energy Analysis
BNDES/CTBE study: 2G ethanol perspective in Brazil (2015)

1. 14 scenarios on the 2G evolution from 2016 to 2030;
2. Exploration of alternatives routes and simulation of their effects in the ethanol competitiveness;
3. New feedstocks, reduction of off season, economy of scale, processes integration...
4. An agenda on innovation in the sugarcane based industry
POLICY INITIATIVES

• No specific policy framework for BBE or biochemicals

• Reviewed studies can be seen as basis for a specific policy in the next years

• PAISS (Joint Plan for Supporting Innovation in the sugar-based Energy and Chemical Industries)
PAISS (2011) in brief:

What?
Joint plan (BNDES and FINEP) to finance innovation in the sugar-based ethanol and chemical sectors

Why?
To foster, select and finance initiatives (business plans) that focus on developing, producing and commercializing new industrial technologies to process the sugarcane biomass

What did it offer?
Coordination of the efforts between the BNDES and FINEP focusing on specific research lines. All available financial instruments.

What were the focal points?
   i) Cellulosic Ethanol; ii) New sugarcane-based products; iii) Gasification

Budget
US$ 500 mi

Source: BNDES
35 Business Plans approved will result in a potential investment of BRL 3.4 bn (~ USD 1.7 bn), which represents a dramatic increase.
PAISS: new scenario in 2G ethanol

Estimates of cellulosic ethanol production for 2015 (million liters)*

Before PAISS*

Previous estimates for 2014

After PAISS

Current estimates for 2015

Due to PAISS cellulosic ethanol projects and the delay or standstill of US and EU projects, now Brazil can celebrate a quite different scenario in the race for advanced biofuels.

Source: FO Licht, Nyko et al (2010) and BNDES.

(*) Before-PAISS estimates refer to 2014.
## PAISS Agriculture (2014)

<table>
<thead>
<tr>
<th>R&amp;D Focus</th>
<th>Nº Business Plans</th>
<th>Value (US$ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetic improvement</td>
<td>6</td>
<td>135</td>
</tr>
<tr>
<td>Machinery and equipment</td>
<td>5</td>
<td>219</td>
</tr>
<tr>
<td>Planning and production systems</td>
<td>12</td>
<td>220</td>
</tr>
<tr>
<td>Seedling production</td>
<td>6</td>
<td>72</td>
</tr>
<tr>
<td>Industrial systems for new energy crops compatible to sugarcane cycle</td>
<td>6</td>
<td>202</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>35</strong></td>
<td><strong>849</strong></td>
</tr>
</tbody>
</table>

Source: BNDES
2G Ethanol

1. GRANBIO (1st commercial plant, just started, from straw, Beta Renewables technology, Novozymes enzymes and DSM yeast)
2. Raizen (Shell/Cosan) – operational, integrated to 1G, from bagasse, Iogen technology
3. Abengoa – under construction
4. CTC (technology development)
5. Petrobras – announced?
6. Odebrecht Agroindustrial – planned?
7. Dow – planned?
Industry initiatives

New products based on ethanol

• Braskem – Green PE – 200 kt/y (2011)

New products based on sugar

• Amyris – farnesene – commercial (2013)

• Solazyme/Bunge – special oils – commercial (2014)
Industry initiatives

Under development

• Braskem/Genomatica – butadiene from sugar
• Braskem/Amyris/Michelin – isoprene from sugar

Announced/Planned

• Granbio/Solvay – butanol from sugar
• Elekeiroz, based on Coskata technology – butanol from syngas
• Bunge/Proterro (pilot, sucrose production)
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My last word

• To go beyond ethanol Brazil has to design a new agenda of innovation on BE/BBE;

• Some important pieces are available;

• So, the challenge is launched!

Obrigado

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GEB – Grupo de Estudos em Bioeconomia