Bioenergy development and deployment: getting benefits from the use of international cooperation

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The Brazilian Alcohol Program

- **1975 PROALCOOL:**
  - sugarcane ethanol for the oil shock
  - mandatory blend to gasoline (20 - 26% vol.)
  - high-octane fuel in vehicles, replacing lead and/or MTBE

- **2005:**
  - fully competitive to gasoline: 2.5 bln liters exports (2004)
  - 14.8 Mm3 consumed
  - saving 35.1 Mt CO2 eq (~ 14% of national CO2 emissions from fossil fuels)
  - increased mechanical harvesting and productivity high industrial (70 - 100 l/tc) and agricultural productivity (60 - 100 tc/ha).
  - 3.5 mln pure ethanol cars and 0.35 mln FFVs

- **Perspectives to 2010:**
  - increased production to 17.3 million m3 of ethanol
  - avoiding 46.7 Mt CO2 eq
Sugarcane vs. other feedstocks

![Bar graph comparing energy output/input ratio for different ethanol feedstocks. Sugarcane has the highest ratio, followed by wheat straw, wood, corn, and sugar beet.](image-url)
Ethanol international competitiveness

- Ethanol prices in Brazil
- Ethanol price with import duty in the EC (US$0.1/l)
- Long-term trend (Rotterdam gasoline prices)
- Long-term trend (Ethanol prices)
- Sugar beet ethanol production cost, UK (US$/GJ)

Graph showing the cumulative production of ethanol in thousand m3 from 1980 to 2005, with prices in US$ per GJ.
# Sugarcane in the world today

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>Agricultural Area (million ha)</th>
<th>Sugarcane area harvested (million ha)</th>
<th>Area ratio Sugarcane/Agricultural</th>
<th>Sugarcane production (million t)</th>
<th>Sugarcane production (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td></td>
<td>5022</td>
<td>19,7</td>
<td>0,4%</td>
<td>1271</td>
<td>65</td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td>263</td>
<td>5,0</td>
<td>1,9%</td>
<td>346</td>
<td>70</td>
</tr>
<tr>
<td>64 Low-Income Countries</td>
<td>1421</td>
<td>7,2</td>
<td>0,5%</td>
<td>437</td>
<td>61</td>
<td></td>
</tr>
</tbody>
</table>

Source: www.fao.org
## Sugarcane in the world today

<table>
<thead>
<tr>
<th>Year</th>
<th>2003</th>
<th>2015</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planted area (Mha)</td>
<td>(1)</td>
<td>2.6</td>
<td>45</td>
</tr>
<tr>
<td>Sugarcane yield (t/ha)</td>
<td>(2)</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>Ethanol production (billion l)</td>
<td>(3)</td>
<td>16</td>
<td>432</td>
</tr>
<tr>
<td>Gasoline equivalent production (Million bbl/day)</td>
<td></td>
<td>0.21</td>
<td>5.75</td>
</tr>
<tr>
<td>Electricity Generation (TWh/yr)</td>
<td>(4)</td>
<td>9</td>
<td>1039</td>
</tr>
</tbody>
</table>

Notes: (1) Annual area increase = 8%; (2) Annual productivity increase = 3% (3) Annual ethanol yield increase per tonne of sugarcane = 0.5%; (4) Electricity generation based in high pressure steam turbine Uses all bagasse and 60% of tops and leaves. Yield is 230 kWh/tonne of sugar cane after the tenth year and grows linearly from 50kWh in 2003 to 230kWh.
FAO's sugarcane potentials

SI: suitability index

VERY SUITABLE AND SUITABLE POTENTIAL LAND AREA FOR SUGARCANE CROPS IN MAJOR 26 COUNTRIES PRODUCERS- HIGH, MEDIUM AND LOW INPUT EFFORT - FOREST AREA EXCLUDED - Thousand Ha

Paraguay, 7013  
Mexico, 5558  
Bolivia, 4591  
Madagascar, 4591  
United States, 4559  
Colombia, 4058  
Cent. Afr. Rep., 3632  
Congo, 3470  
Cameroon, 3451  
Bangladesh, 3437  
Indonesia, 14356  
Argentina, 11039  
Liberia, 2566  
Mozambique, 2524  
Philippines, 3190  
Liberia, 2566  
Venezuela, 2499  
Malaysia, 2220  
Guyana, 1360  
Uganda, 3386  
Cote d’Ivoire, 3206  
India, 3234  
Gabon, 3384

Potential ethanoL production (@ 6000 l/ha.yr): 1146 billion liters/ year  
Equivalent to 611 Mtoe (62% of OECD´s petroleum products consumption in road transport, 2000)


Total area in the largest 26 producers = 169 Million ha  
Total area in all producers = 191 Million ha; equiv 1.46% of all land area ; 51% of total potential sugarcane area

SOURCE: FAOSTAT
## Ambitious hypothetical scenarios

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>OECD</th>
<th>Non-OECD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gasoline consumption</strong></td>
<td>1165</td>
<td>838</td>
<td>327</td>
</tr>
<tr>
<td><strong>Ethanol 10% blend</strong></td>
<td>175</td>
<td>126</td>
<td>49</td>
</tr>
<tr>
<td><strong>E100</strong></td>
<td>1748</td>
<td>1257</td>
<td>491</td>
</tr>
<tr>
<td><strong>Sugarcane area for E10</strong></td>
<td>29</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td><strong>Sugarcane area for E100</strong></td>
<td>291</td>
<td>210</td>
<td>82</td>
</tr>
<tr>
<td>&quot;Suitable&quot; and &quot;very suitable&quot; sugar crops (FAO)</td>
<td>383</td>
<td>116</td>
<td>217</td>
</tr>
<tr>
<td><strong>All sugar crops (all cultures, FAO)</strong></td>
<td>1455</td>
<td>496</td>
<td>959</td>
</tr>
</tbody>
</table>

* @ 6000 l ethanol/ha.yr; gasoline 33MJ/liter, ethanol 22 MJ/liter