

# Mapping of biofuels R&D in Brazil

Report from an f3 synthesis project

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Innventia



# Project outline

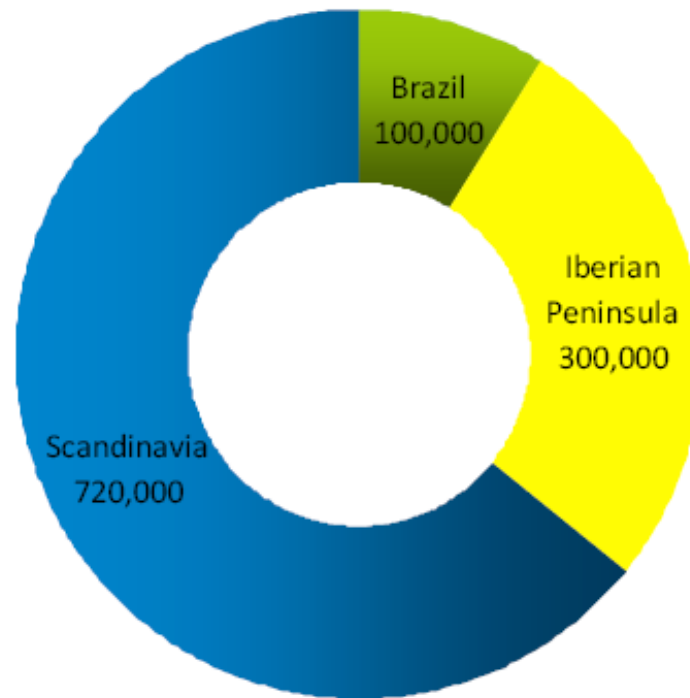
- Project goal
  - A comprehensive list of ongoing R&D activities and actors related to biofuels in Brazil, and possibilities for collaboration with f<sup>3</sup>.
- Activities
  - Web and literature searches to identify the most important R&D actors.
  - Interviews with people in our existing network.
  - Meetings with some key actors.
  - Short background on biofuels use for transportation in Brazil, including production, use, legal framework. Include comparison with other countries in Latin America, if information is easily available.
- Time plan
  - February 2012 - June 2012. Preliminary results will be discussed at the f<sup>3</sup> workshop in March.
- Budget
  - 100 kkr (including 10 kkr for part of travel costs, travel will be coordinated with work in other projects).

# BACKGROUND

# Latin America



# Forest Area (ha) Required for a 1,0 million tons/year Admit Pulp Mill



Source: Pöyry

# Biofuel incentives and production in Latin America

- **Argentina**

- Promotion scheme for production and sustainable use of biofuels by 15 years. E5 required by 2010.
- Projected ethanol production for 2011: 243 million liters

- **Brazil**

- 1st phase 1931: Addition of 5% alcohol to imported gasoline.
- 2nd phase 1975: Equilibrium in balance of payments with reduction of dependence on foreign oil.
- 2010-2011 production season: 27,600 million liters of alcohol ((8,107 million liters anhydrous and 19,592 million liters hydrated)

- **Chile**

- Decree 2008: Defined quality specifications for ethanol, allowed 5% blends with gasoline.
- 2011: construction of pilot plant – second generation ethanol

- **Colombia**

- Law 2001: Enacted the Biogasoline Program. Requires that petrol distributed to all cities with over 500,000 inhabitants, has to contain 10% ethanol.
- 2010: Produced 287 million liters; five (5) existing sugarcane mills and one (1) cassava mill: 390 million liters total installed capacity.

- **Ecuador**

- Decree 2004: Declared production, marketing and use of biofuels as of national interest.
- Pilot Plant Guayaquil: supplies 50,000 l/d of anhydrous ethanol to add 5% into high-octane gasoline.

*Source: Rico et al, 2011*

# Biofuel incentives and production in Latin America

## ▪ Paraguay

- Decree 1999: Blend with gasoline established at up to 20%.
- Law 2005: Declares biofuels production as national interest.
- Nine existing sugarcane mills: 250 million liters per year total installed capacity. No production data available.

## ▪ Peru

- Law 2003: Promotes biofuels markets, agricultural and agro-industry development and provides an alternative market in the fight against drugs. Since January 2010, 7.8% blend is mandatory.
- No production data available.

## ▪ Uruguay

- Law 2007: At least E5 ethanol until 31/12/2014
- 70 million liters per year starting 2012

## ▪ Costa Rica

- Decree 2003: Promotes schemes for production and use of biofuels E5.
- 2011 production: 40 million liters

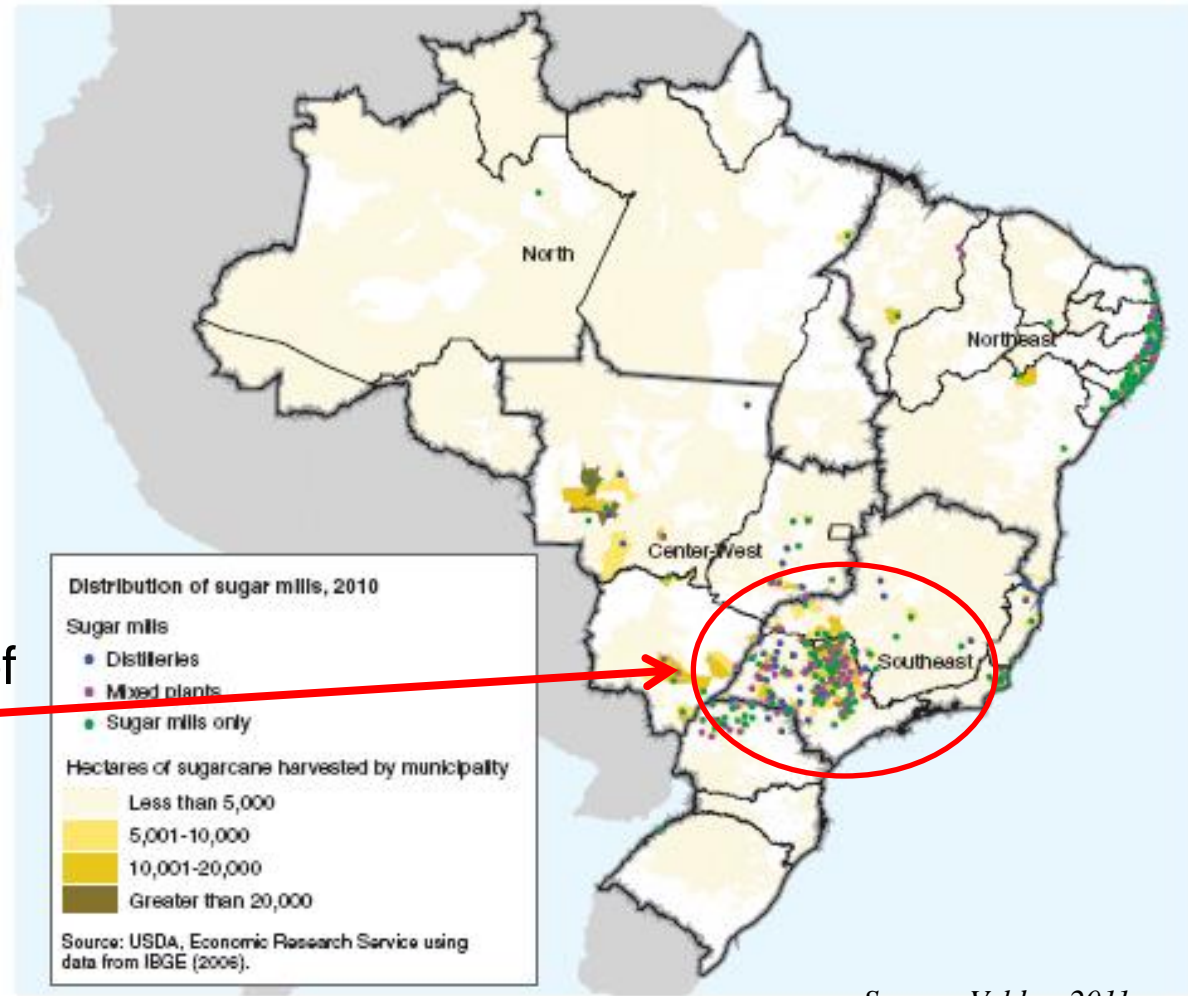
## ▪ Guatemala

- Decree 2003: Promotes schemes for biofuels production.
- 2011 production: 250 million liters, 80% for export to Europe and USA.

*Source: Rico et al, 2011*

# Ethanol producers in Brazil

- Total ethanol production 31 billion liters (2010)
- 38% of global production
- Concentrated to Southeast
- 2/3 of all sugarcane is produced in the state of São Paulo



Source: Valdes, 2011

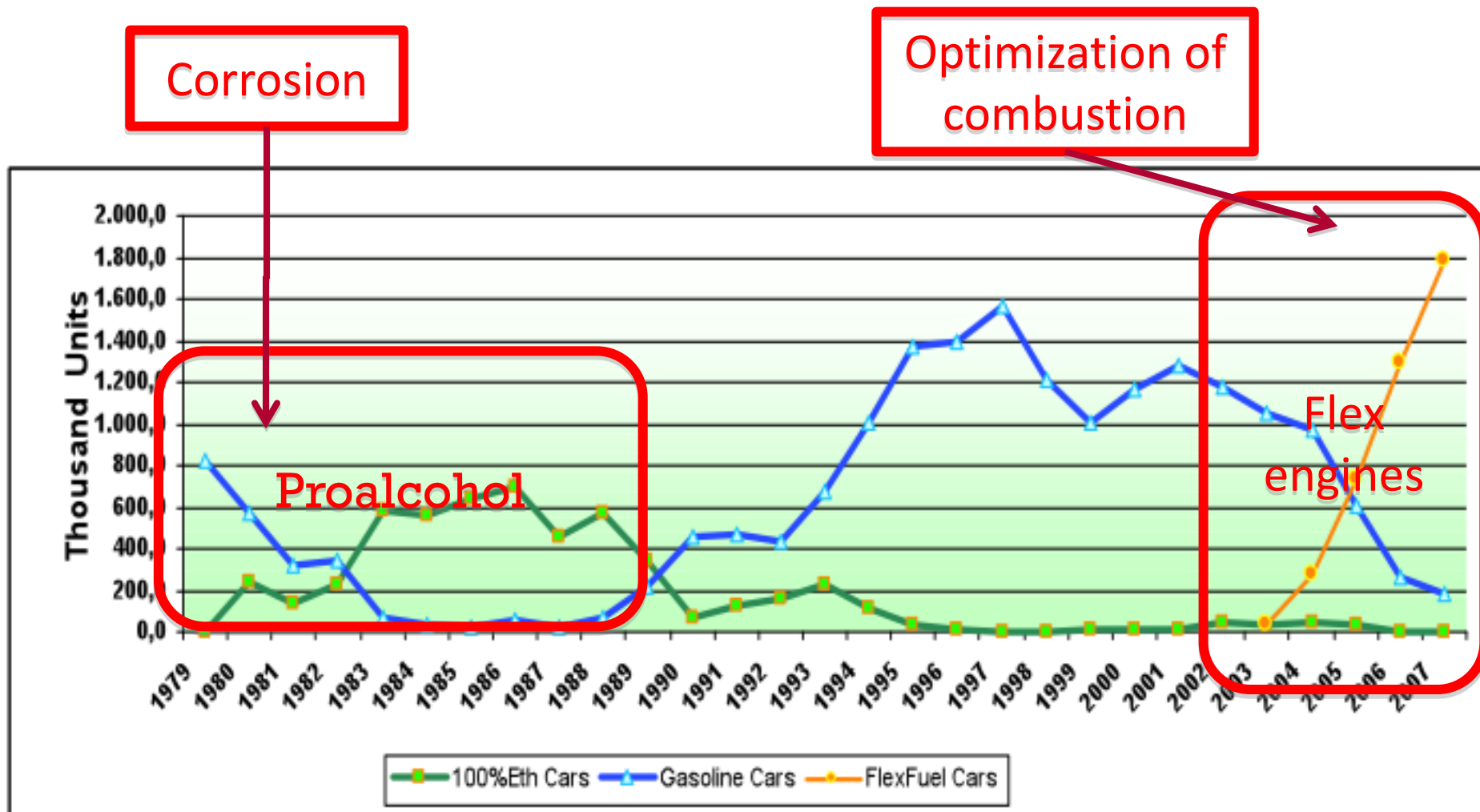


# Ethanol as a motor fuel in Brazil

- Started in 1975 with the “Proálcool” program
- Now replacing 56% of gasoline use
- Two methods to introduce into fuel pool
  - Anhydrous ethanol used in E25 blend with gasoline
  - Hydrous ethanol E100 used in dedicated engines and in newer flex-fuel vehicles (FFVs)
- No subsidies for the ethanol product
- 95% of new cars are FFVs
- Currently a shortage of ethanol in Brazil, leading to import!

*Source: Valdes, 2011*

# Cars selling of light vehicles in Brazil (1979-2007)



# RESEARCH PROGRAMS

# BIOEN Program

- Funded by FAPESP (São Paulo Research Foundation)
- Started in 2008
- Five research areas:
  - Biomass Research, with focus on sugarcane and including plant improvement and sugarcane farming;
  - Ethanol Industrial Technologies;
  - Bio-refineries Technologies and Alcohol Chemistry;
  - Applications for Motor Vehicles: Otto cycle engines and fuel cells;
  - Research on Impacts: Social and economic, environmental studies, land use, intellectual property.
- <http://www.fapesp.br>
- <http://bioenfapesp.org>

# PAISS Program

- Funded by BNDES (Br Development Bank) and FINEP (Innovation Agency)
- One billion R\$ 2011-2014
- Aims to support technological innovation in the sugar-based energy and chemicals sector
- Focus on 2<sup>nd</sup> generation biofuels
- Three thematic areas:
  - 2<sup>nd</sup> generation ethanol
  - New products from sugarcane
  - Gasification
- [http://www.bndes.gov.br/SiteBNDES/bndes/bndes\\_pt/Areas\\_de\\_Atualizacao/Inovacao/paiss/](http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Areas_de_Atualizacao/Inovacao/paiss/)

# Important R&D Actors

- USP\* - University of São Paulo
- UNICAMP\* - Universidade Estadual de Campinas
- UFMG - Federal University of Minas Gerais
- UFRJ\* - Federal University of Rio de Janeiro
- UnB - University of Brasília
- UFABC\* - Universidade Federal do ABC
- EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Corporation)
- CTC\* – Centro de Tecnologia Canavieira (Sugarcane Technology Center)
- CTBE\* – Laboratório Nacional de Ciência e Tecnologia do Bioetanol (Brazilian Bioethanol Science & Technology Laboratory)

\* Visited by Innventia

# MEETINGS WITH UNIVERSITIES

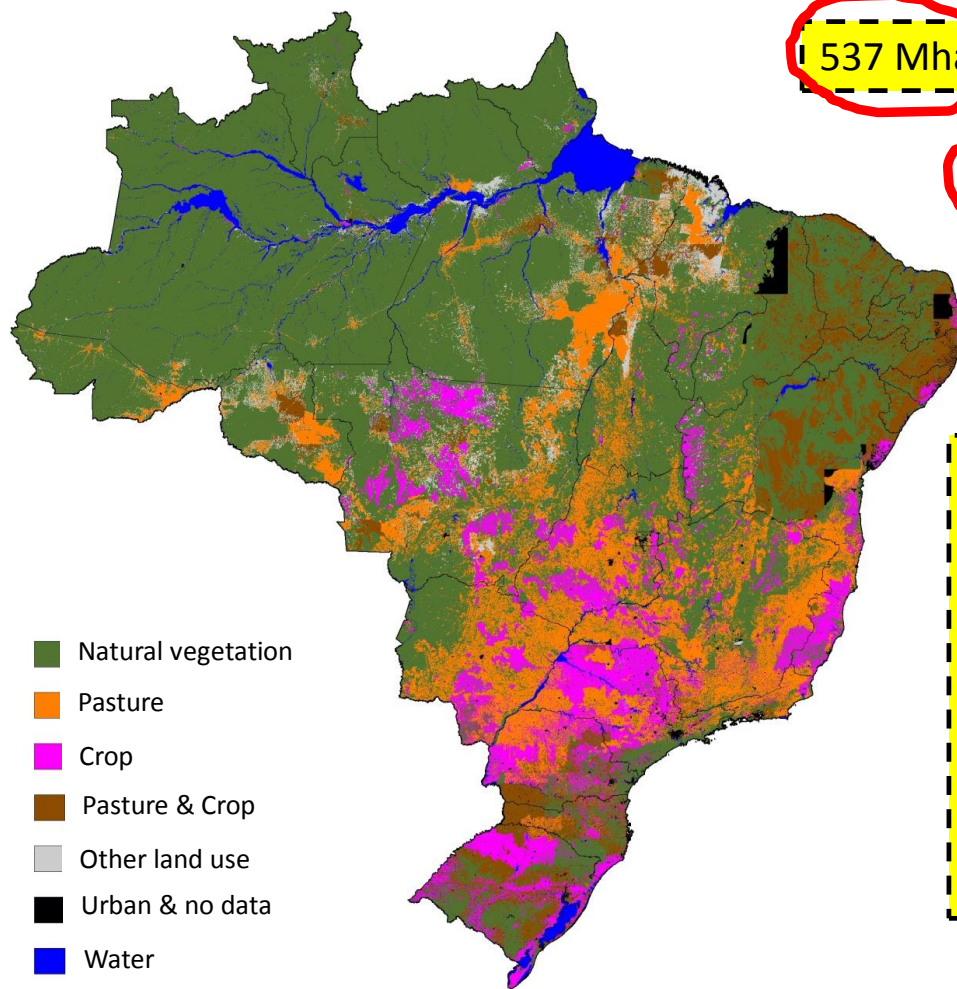
# USP-ESALQ

- Escola Superior de Agricultura "Luiz de Queiroz"
- Agricultural university in Piracicaba
- Contacts at ESALQ
  - Professor Gerd Sparovek
    - Research on land use change
    - Collaboration with Chalmers (Göran Berndes)
  - Professor Francides Gomes
    - Pulping
- <http://www.esalq.usp.br/>





# 850 Mha



537 Mha (60%) = Natural vegetation

211 Mha

Pasture and Pasture & Crop land  
app. 200 M head

67 Mha

Crop land and planted forests

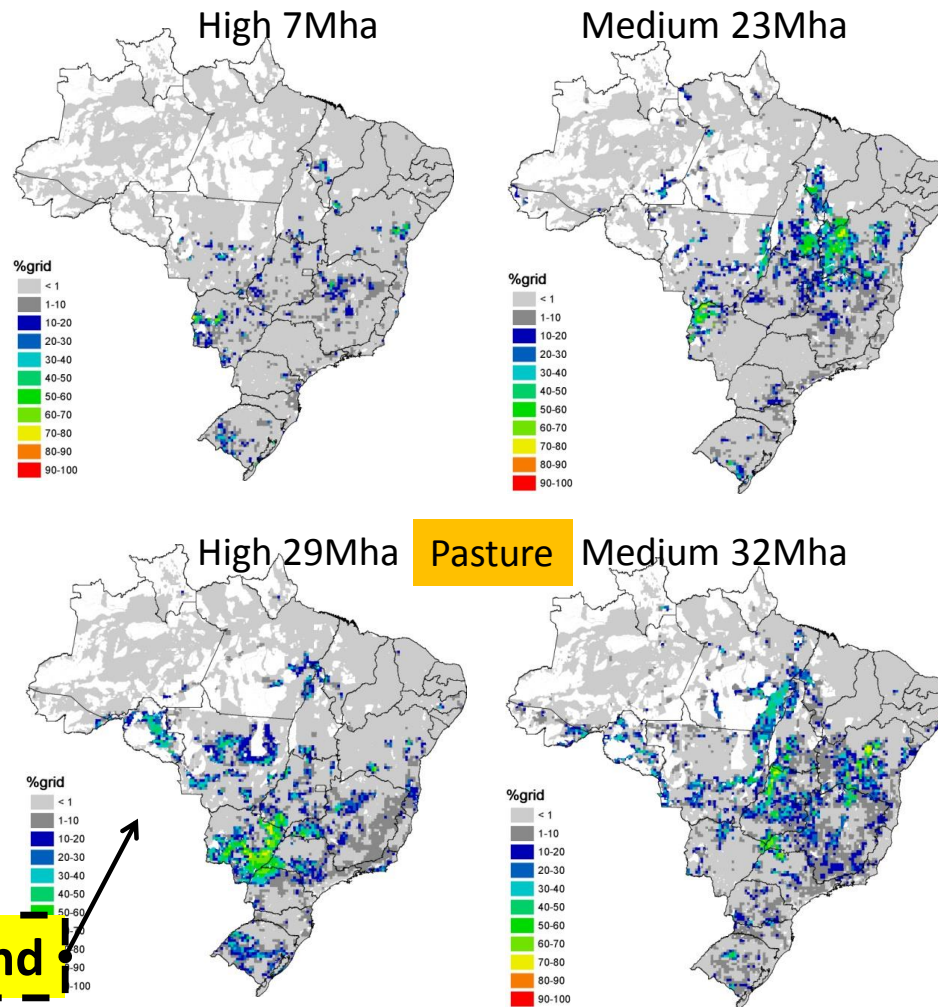
Soy	22 Mha
Corn	13
Cane	8
Euc/Pine forest	8
Beans	4

Source: Sparovek (USP-ESALQ), 2012

## Agricultural development: Crop land expansion

## Suitability for crops: climate, slope, soil

### Natural Vegetation



Source: Sparovek (USP-ESALQ), 2012



**Cane  
residues**

**Beef cattle production development  
Intensification**

**Cattle production can release 69 Mha of  
land with minor intensification**

Herd (M head)	180		133
Stocking rate (head/ha)	1.14		1.50
Off-take rate (% y)	22		30
Slaughter rate (M head/y)	40		40
Area (Mha)	158	→	89

**Integration with crops**

Censo 2006

Source: Sparovek (USP-ESALQ), 2012

# UFRJ

## Federal University of Rio de Janeiro

- New laboratory starting up in 2012
- Contacts at UFRJ:
  - Professor Elba Bon
    - Research focus is on enzymatic hydrolysis including production of enzymes
  - Professor Nei Pereira
  - Professor Rogerio Valle
    - Life Cycle Management



# Work at IQ/UFRJ



- Biomass availability
- Biomass Pretreatment
- Enzyme Production
- Enzymatic Hydrolysis
- Enzyme Characterization

*Source: Bon (UFRJ), 2012*

Waste Biomass Valor (2010) 1:65–76  
DOI 10.1007/s12649-010-9008-8

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### Biomass Residues in Brazil: Availability and Potential Uses

Viridiana Ferreira-Leitão • Leda Maria Fortes Gottschalk •  
Maria Antonieta Ferrara • Alexandre Lima Nepomuceno •  
Hugo Bruno Correa Molinari • Elba P. S. Bon

Received: 11 November 2009 / Accepted: 4 January 2010 / Published online: 7 February 2010  
© Springer Science+Business Media B.V. 2010

#### Potential for second-generation ethanol production from biomass, per year, in Brazil:

- From the sugar cane residues: 23.7 billion liters;
- From corn residues: 4.4 billion liters;
- From wheat residues: 0.6 billion liters.

**Considering that the annual production of first generation ethanol amounts 27.5 billion liters, the conversion of the cellulose part from these agricultural residues could increase ethanol production in Brazil over two fold, without increasing the farming area.**

*Source: Bon (UFRJ), 2012*



# POTENTIAL FOR SECOND-GENERATION ETHANOL PRODUCTION FROM SUGARCANE BIOMASS

**1 ton of sugarcane** {  
**340 Kg of straw (10% humidity)**  
**300 Kg of bagasse (50% humidity)**  
**360 Kg of sucrose juice**  
**80L of ethanol (1<sup>st</sup> generation)**

**88% bagasse** → **energy cogeneration**

**50% straw must be left in the ground for soil protection**

**Biomass availability: 12% bagasse (18 Kg) + 50% straw (153 Kg)**

**36,5L of ethanol from cellulose**  
**(assuming biomass cellulose content of 30% and ethanol density of 0.79 g/cm<sup>3</sup>)**

Waste Biomass Valor (2010) 1:65–76  
DOI 10.1007/s12649-010-9008-8

Source: Bon (UFRJ), 2012

# Steam explosion in the presence of CO<sub>2</sub>

Collaboration with Lund University - Sweden



Untreated bagasse



Steam explosion  
treated bagasse



UFRJ (Brazil) - Lund University (Sweden) collaboration project  
received financial support from STINT

Source: Bon (UFRJ), 2012



# UNICAMP

- Universidade Estadual de Campinas
- Contacts at UNICAMP
  - Professor Maria Aparecida Silva
    - Biomass pretreatment
    - Process integration
  - Professor Caio Glauco Sanchez
    - Gasification and pyrolysis
    - Collaboration with KTH
- <http://www.unicamp.br/>



# UFABC

- Universidade Federal do ABC in São Antonio
- Contacts at UFABC
  - Professor Silvia Azucena Nebra
    - Process simulation
  - Professor Adriano Ensinas
    - Process integration
- <http://www.ufabc.edu.br/>

# MEETINGS WITH INSTITUTES AND COMPANIES

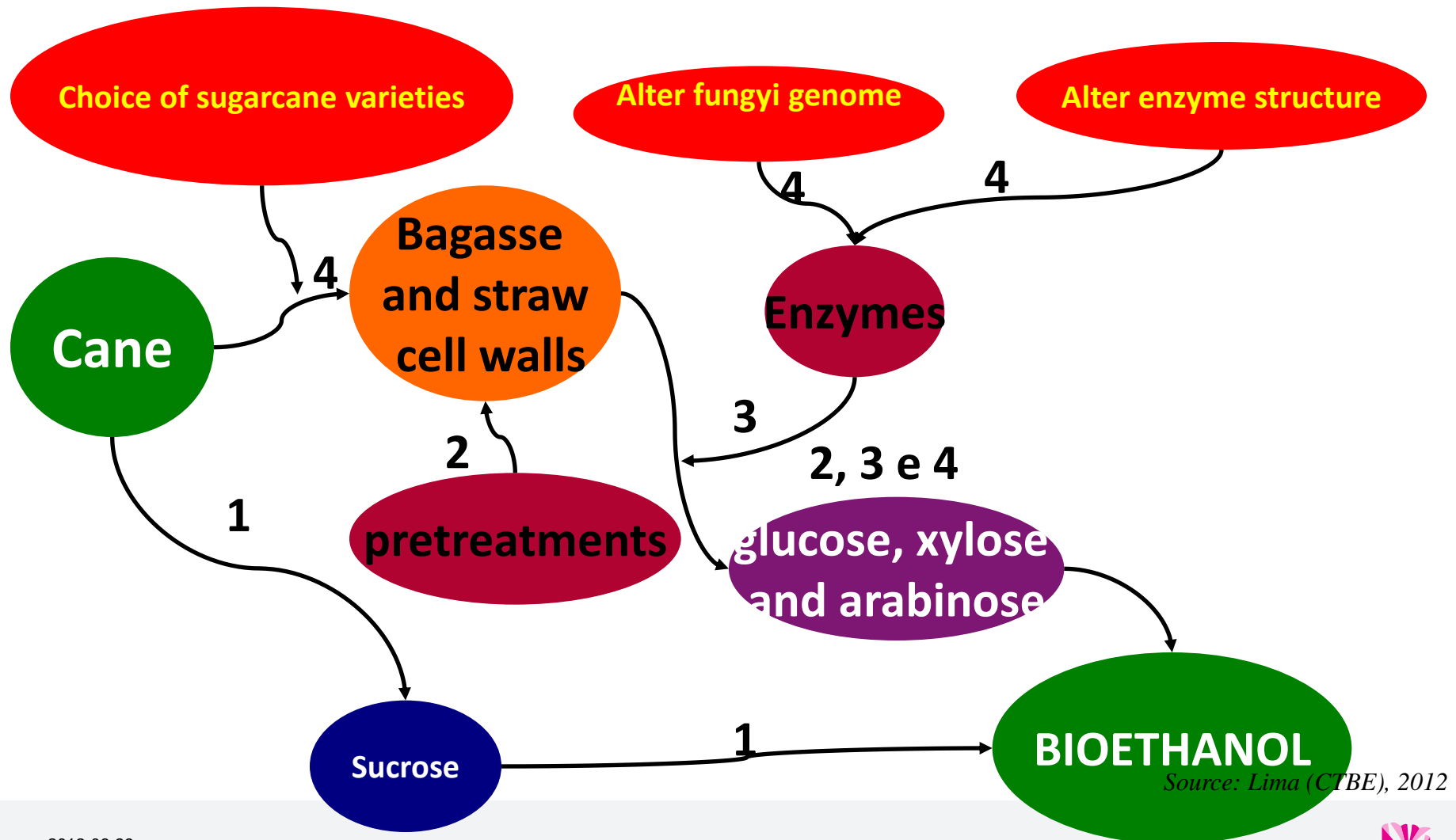
## Brazilian Bioethanol Science and Technology Lab

*What does Brazil need to do for replacing 10% of the world demand of gasoline by ethanol from sugarcane by the year 2025?*

- A research institute, performing RD&I for improving feedstock and conversion routes for bioethanol production from sugarcane
- Research areas:
  - Basic science
  - Low-impact mechanization
  - Virtual biorefinery
- Open for international collaboration
- Contacts at CTBE
  - Marco Lima
  - Antonio Bonomi
  - Marcus Buckeridge
- <http://www.bioetanol.org.br/>



# Brazilian route to obtain 2nd generation bioethanol – next 3 to 5 years





# New pilot plant at CTBE



- Process development to test:
  - physical/chemical pretreatment
  - production of microorganisms (fungi yeasts and bacteria)
  - enzymatic hydrolysis
  - extraction and purification
  - alcoholic fermentation



# CTC – Sugarcane Technology Center

- Since 1969 CTC has played an important role in the ongoing evolution of sugar cane production and processing
- Located in Piracicaba, São Paulo with laboratories equipped with state-of-the-art technologies
- At the breeding station in Bahia, CTC maintains the world's largest and most complete germplasm bank, consisting of more than 5000 clones of commercial and wild species of sugarcane.
- Associated companies are currently 143 mills and 17 canegrowers associations, which represent 12 000 sugarcane planters. The sugarcane volume of these associates represents approximately 60% of all sugarcane in Brazil.
- Contacts at CTC:
  - Jaime Finguerut
  - Thomas Ritter
- [www.ctc.com.br](http://www.ctc.com.br)



- Started in 2007, ETH Bioenergia, works with the production, sales and logistics of ethanol, electric energy and sugar
- 3 billion liters of ethanol will be produced by ETH in 2013
- The ETH business model is based on three production poles, located in the states of São Paulo, Mato Grosso do Sul and Goiás
- Plan to have 9 mills by the end of 2012, fully mechanized, no manual operations
- Contact at ETH:
  - Carlos Calmanovici





# CONCLUSIONS AND WAY FORWARD

# Conclusions

- The Latin American perspective
  - Brazil is by far the largest producer of biofuels in Latin America
  - Incentives in place for more than 35 years
  - Most Latin American countries have mandates to blend ethanol into gasoline
- Ongoing R&D activities related to biofuels in Brazil
  - Very large investments in biofuels R&D, corresponding to > 1 billion SEK per year
  - Bottleneck is to find people with the right competence
  - Focus is on sugarcane ethanol, including the use of bagasse and other residues
  - Most of the research facilities (and production plants) are in the state of São Paulo

# Conclusions, continued

- Possibilities for collaboration with f<sup>3</sup>
  - Universities and institutes are very open to collaboration
- We have good contacts in the f<sup>3</sup> network with:
  - CTBE (Bioethanol Research Institute in Campinas)
  - UNICAMP (State University of Campinas)
  - CTC (Sugarcane Technology Center in Piracicaba)
  - USP-ESALQ (State University of São Paulo in Piracicaba)
  - UFRJ (Federal University of Rio de Janeiro)

# Way forward?

- Vinnova has launched a program to strengthen Swedish R&I centers and clusters in their “strategy to systematically integrate an international perspective”.
  - Call opened in May.
  - Deadline to submit a proposal is **August 21, 2012**.
  - Projects can start late in October and run for one year.
  - Total budget is 8 MSEK. 10-20 projects will be funded.
- Projects should aim to develop processes and tools for exchange of knowledge and competence with research institutions and companies globally.
- Focus should be on collaboration with countries outside the EU and the United States.

# References

- FAPESP, “Brazilian Research on Bioenergy”, June 2012 (<http://bioenfapesp.org>)
- Valdes C, “Brazil’s Ethanol Industry: Looking Forward”, June 2011 ([www.ers.usda.gov](http://www.ers.usda.gov))
- Rico J A P, Rudy-Arellano R, Sauer I L, Mercedes S S, “Incentive mechanisms for the bioethanol production in Latin America: State of the art and perspectives”, *19th Intl Symposium on Alcohol Fuels*, Verona, Italy, October 10-14 (2011).
- Lima M, CTBE, presentation to Innventia in February 2012
- Sparovek G, USP-ESALQ, presentation to Innventia in February 2012
- Bon E, Texheira R, UFRJ, presentation to Innventia in June 2012
- Ferreira-Leita V, Gottschalk L M F, Ferrara M A, Nepomuceno A L, Molinari H B C, Bon E, “Biomass Residues in Brazil: Availability and Potential Uses”, *Waste Biomass Valor* (2010) 1:65–76
- Soccol C R, et al., “Bioethanol from lignocelluloses: Status and perspectives in Brazil”, *Bioresource Technology*, Vol. 101, Issue 13, pp. 4743-5042 (July 2010)
- Dias M, Modesto M, Ensinas A, Nebra S, Filho R M, Rossell C, “Improving bioethanol production from sugarcane: evaluation of distillation, thermal integration and cogeneration systems”, *Energy* 2011(36):3691-3703

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