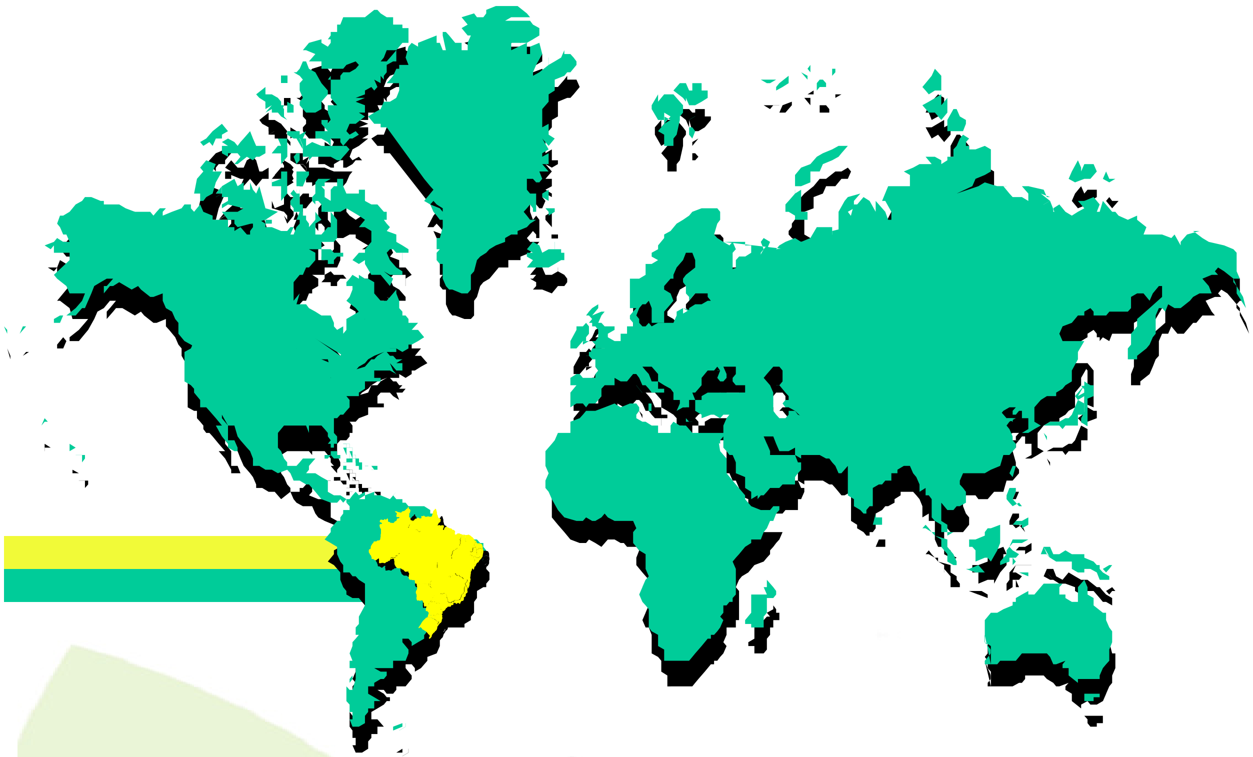
Renewable Energy Development and Use in Brazil

Perspectives for a Brazil-Korea Cooperation in Bioenergy R&D



Mauricio Antonio Lopes, PhD
Embrapa Labex Korea
Rural Development Administration – RDA
Suwon - Republic of Korea

Visit to the Korea Institute of Energy Research – KIER
Daejeon , South Korea - December 21st, 2009

Summary

Introduction

Renewable Energy in Brazil

Sugarcane and Ethanol

Biodiesel Production and Use

Bioenergy R&D Programs in Brazil

Challenges for the Future

Brazil-Korea Cooperation

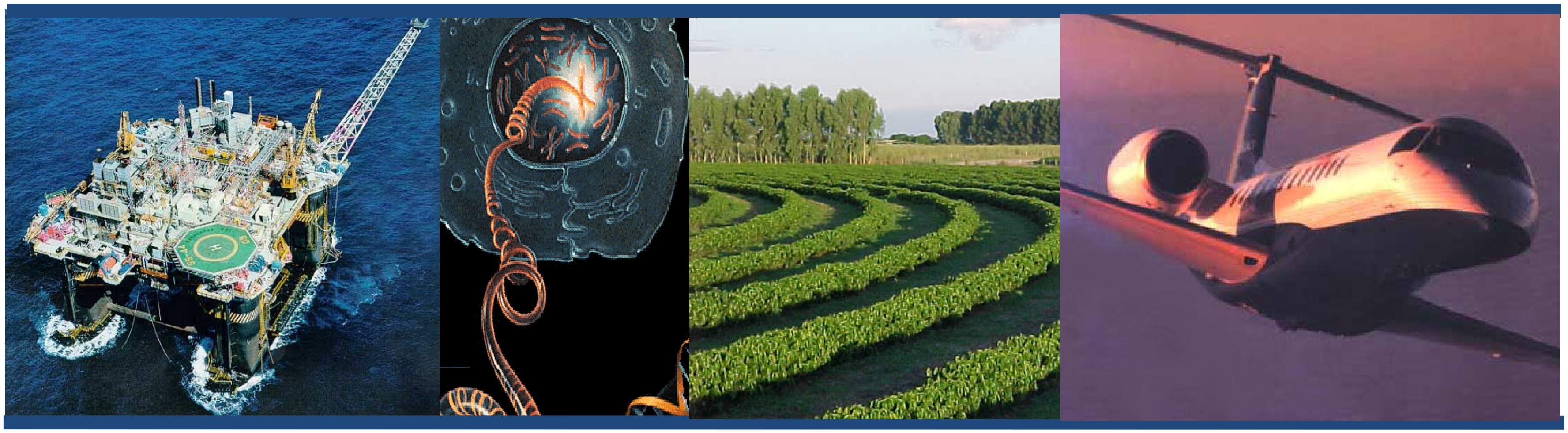
There is a Brazil that most people know

Amazon forest Soccer Carnival Coffee

It keeps being successful, but there is still more to know…

Source: modified from MDIC

The Brazil you must know



Source: modified from MDIC

Technology, Innovation, Competitiveness

A strong academic base

10,000 doctorates every year

> 16,000 scientific articles a year

A growing intensity of industry R&D

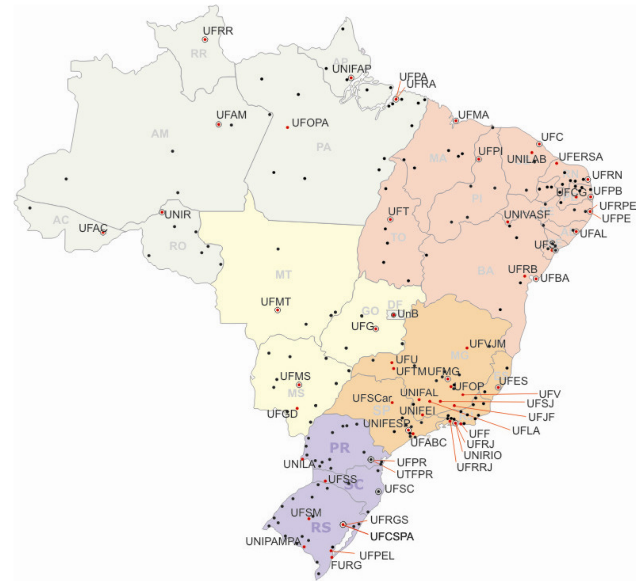
The Brazil you must know

Federal Universities
Situation in 2002

main campi (●) = 43

Federal Universities
Situation in 2002

main campi (●) = 59



Federal Universities
Situation in 2009
Main campi (●) = 59
Other campi (●) = 171
Total = 230

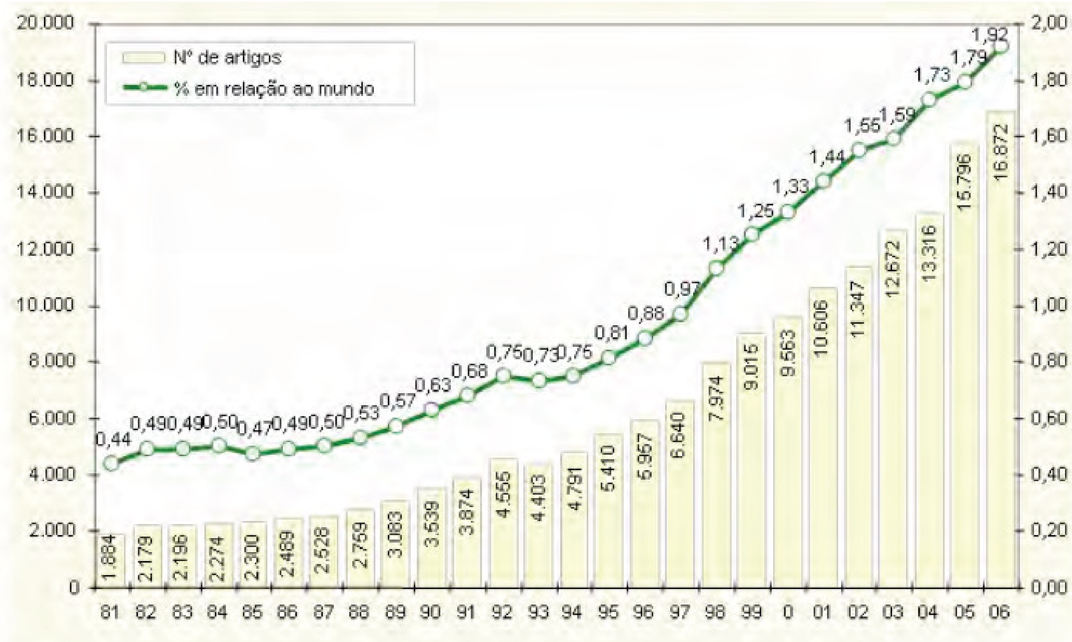
A strong academic base

The Brazil you must know

A strong academic base

Scientific articles publised in internationally indexed periodicals

- based on data from the institute for Scientific Information (ISI) -



Fonte(s): Institute for Scientific Information (ISI). National Science Indicators.

Elaboração: Coordenação-Geral de Indicadores - ASCAV/SEXEC - Ministério da Ciência e Tecnologia.

Atualizada em: 09/07/2008

Available at http://www.schwartzman.org.br/simon/2009_11_abciencias.pdf

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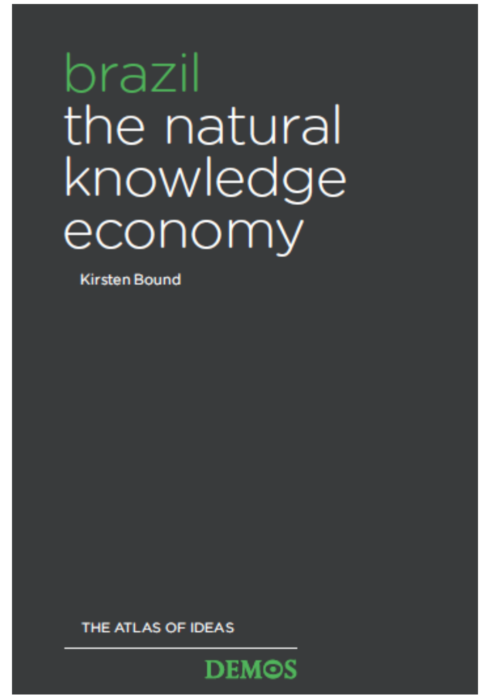
The Brazil you must know

<u>The Economist - Nov. 14-20, 2009</u>

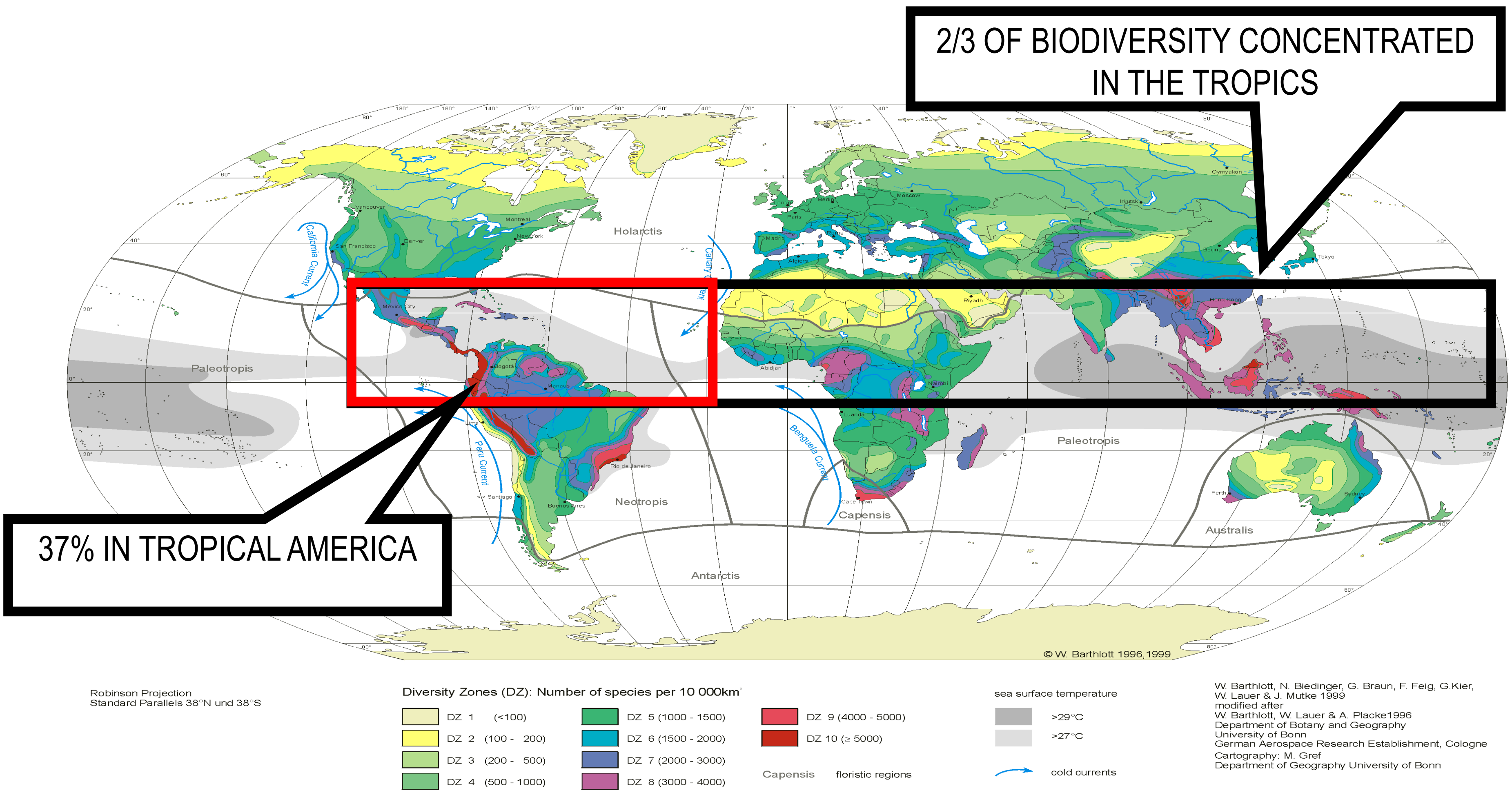
"A country with the world's largest freshwater supplies, the largest tropical forests, fertile land that in some places allows up to three harvests a year, and huge mineral and hydrocarbon wealth."



<u>The Atlas of Ideas – Demos Institute, 2008</u>

"It is helpful to think of Brazil as a 'natural knowledge-economy'… its innovation system is in large part built upon its natural and environmental resources, endowments and assets."

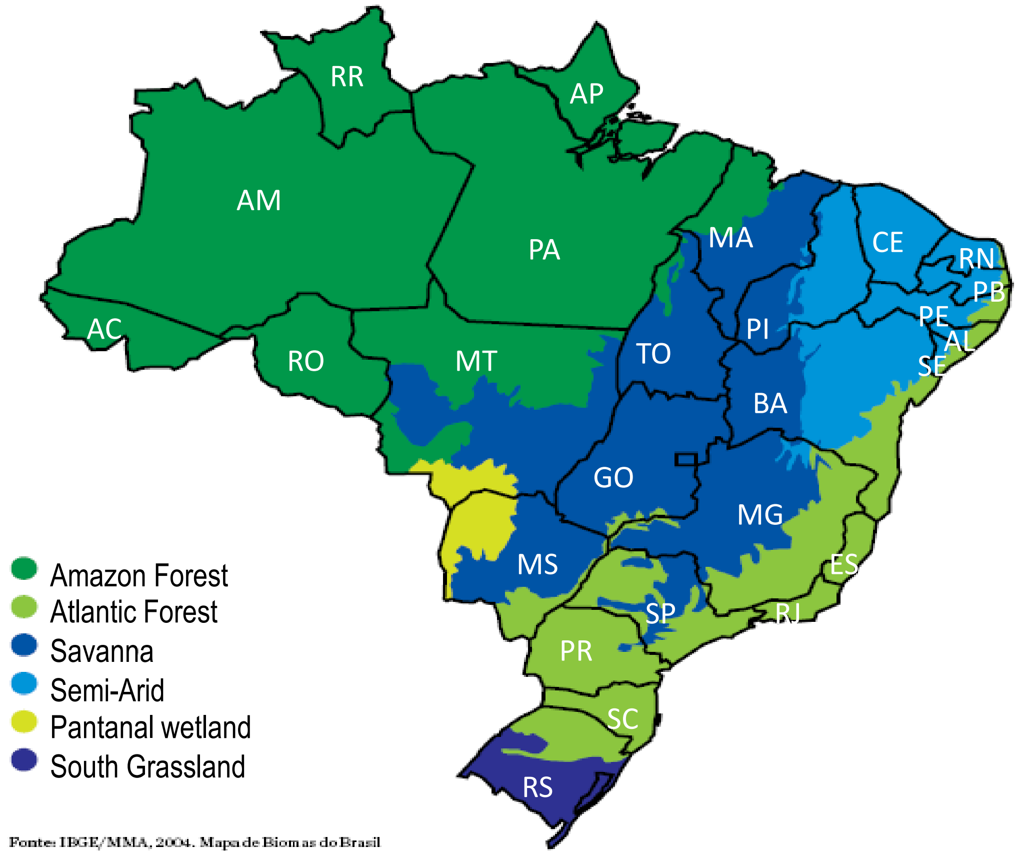
“Brazil: the natural knowledge economy”



Barthlott, W., Biedinger, N., Braun, G., Feig, F., Kier, G. & J. Mutke (1999): Terminological and methodological aspects of the mapping and analysis of global biodiversity. In: Acta Botanica Fennica 162: 103-110.

"Brazil: the natural knowledge economy"

Brazilian Biomes: a rich natural resource base



Fonte: IBGE/MMA, 2004. Mapa de Biomas do Brasil

Brazil has a total area of 850 million ha, most of it dedicated to conservation

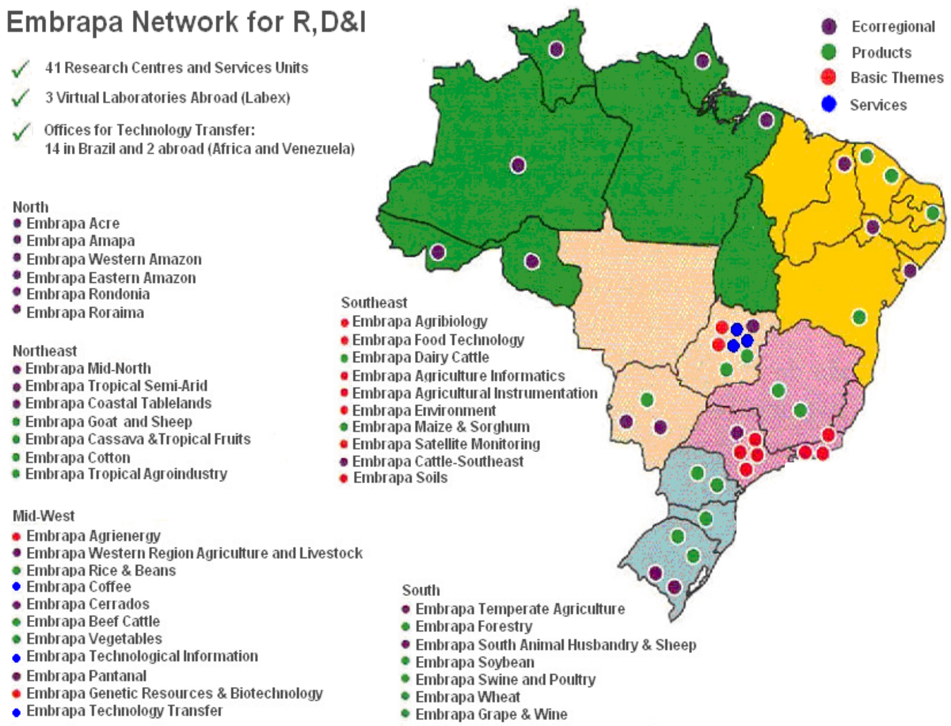
The country has 388 million ha of highly productive arable land, 90 million of which have yet the be farmed

“Brazil: the natural knowledge economy”

Agribusiness in Brazil

Agribusiness in Brazil is driven by innovation

The Brazilian Agricultural Research Organization



Source: ARI/Embrapa

Agribusiness in Brazil is driven by innovation

Exports

In 2008 Brazil exported more than 1500 types of agricultural products to foreign markets

Commercial partners

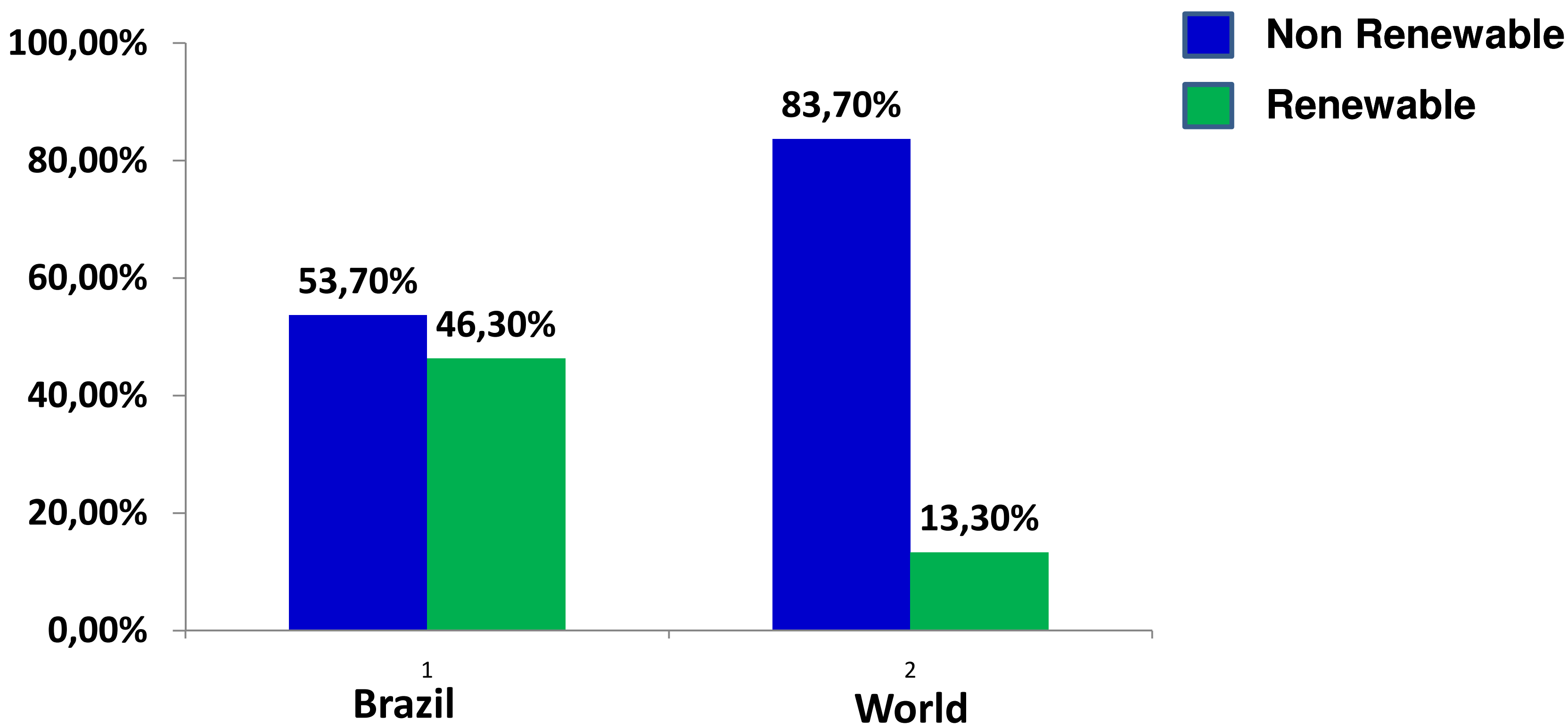
Around 79% of the Brazilian food production is consumed domestically and 21% is shipped to over 212 foreign markets

Product	Production	Exports
Sugar	1st	1st
Orange juice	1st	1st
Coffee	1st	1st
Beef	2nd	1st
Soybean	2nd	1st
Tobacco	3rd	1st
Broiler	3rd	2nd
Corn	3rd	4th

Source: SPA/MAPA (Agricultura Brasileira em Números)

Agribusiness in Brazil – Food, Feed, Fiber and Fuel

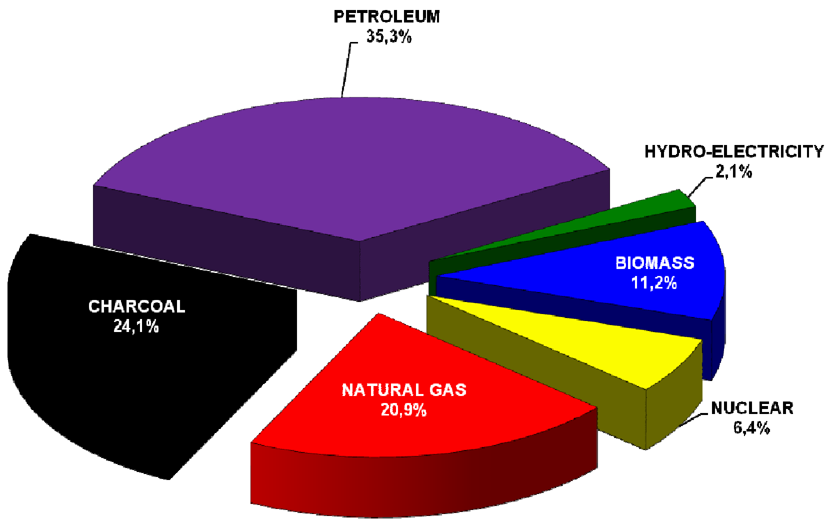
Brazilian vs World Energy Matrix



Source: MME, 2008

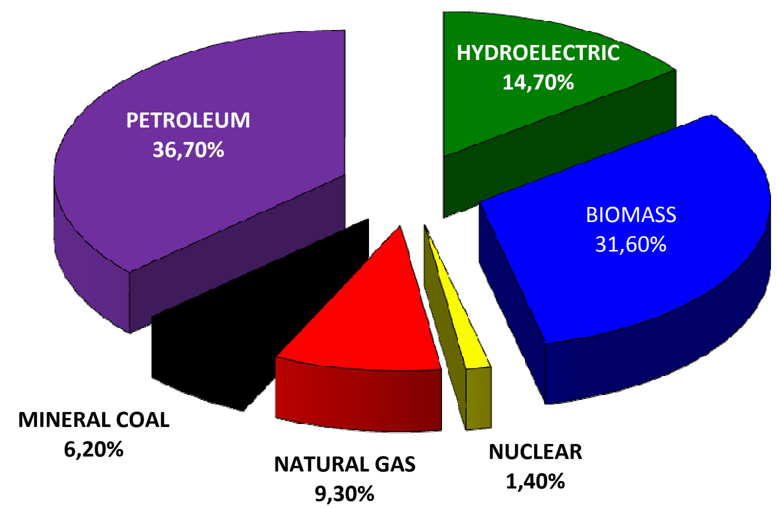
Agribusiness in Brazil – Food, Feed, Fiber and Fuel

World Energy Matrix



Source: IEA, 2008.

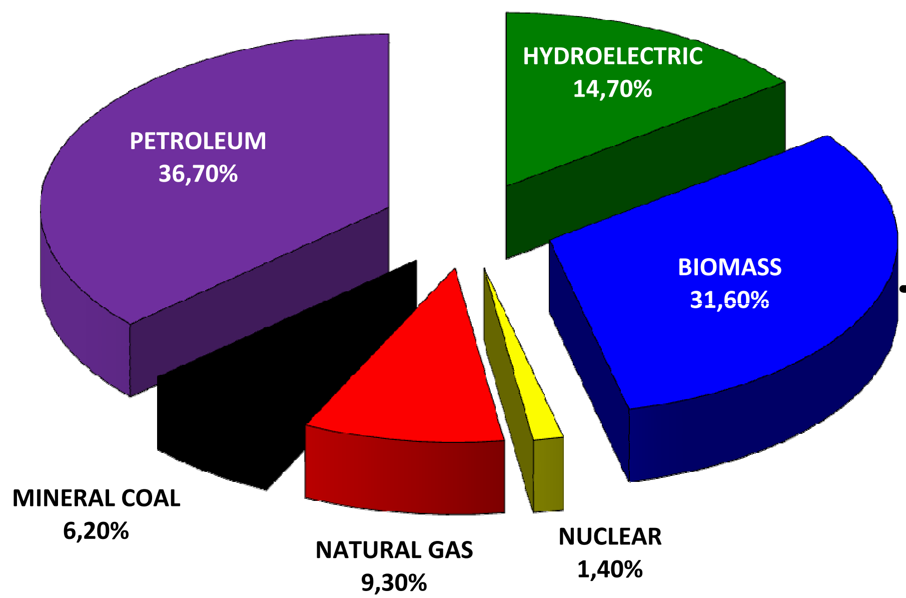
BrazilianEnergy Matrix



Source: EPE, 2008.

Agribusiness in Brazil – Food, Feed, Fiber and Fuel

Brazilian Energy Matrix (% Composition)



Firewood & Charcoal

12,5%

Sugarcane derivatives

16,0%

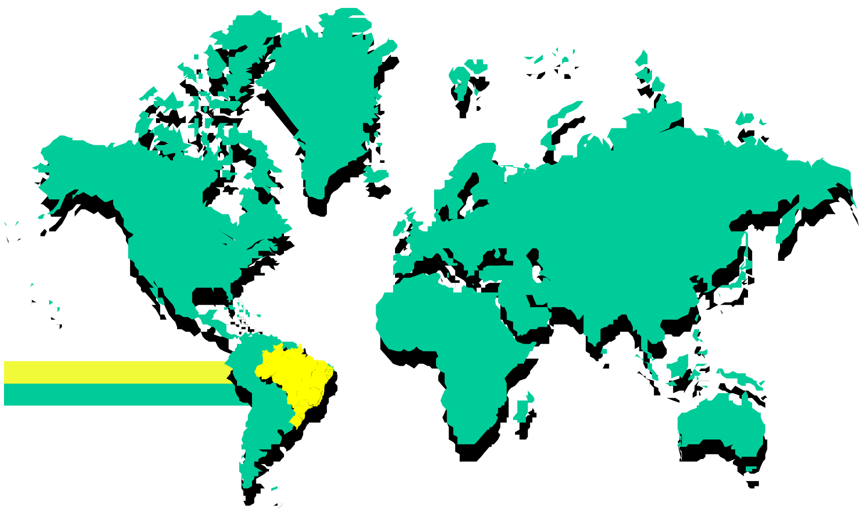
Others

3,1%

Sugarcane surpassed hydroelectric power in the Brazilian energy matrix. Everything indicates that sugarcane will have growing importance in the country´s energy matrix.

Source: EPE, 2008.

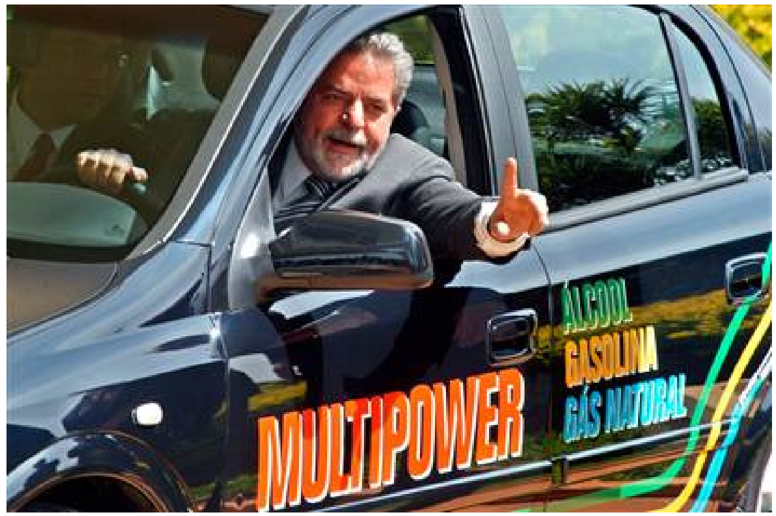
Strong Public Policies Towards Biofuels

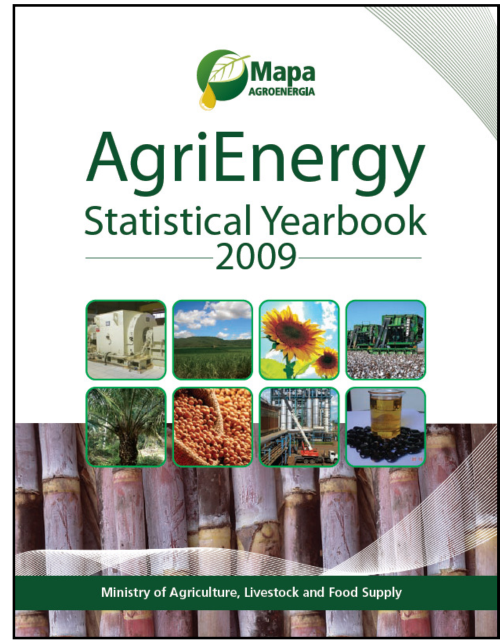


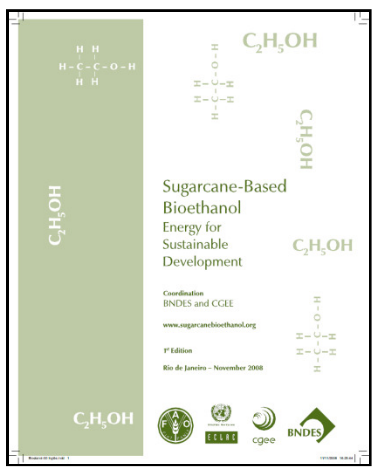
- **Environmental gains**
  - carbon sequestration
  - lower level of emissions
- **Sustainability - Renewable**
  - short production cycle
  - whole process controlled by man
- **Social aspects**
  - generation of new jobs
  - better income distribution
- **Economical aspects**
  - a new global energy demand
  - strong impacts on commerce & trade

Mapa AGROENERGIA

Strong Public Policies Towards Biofuels







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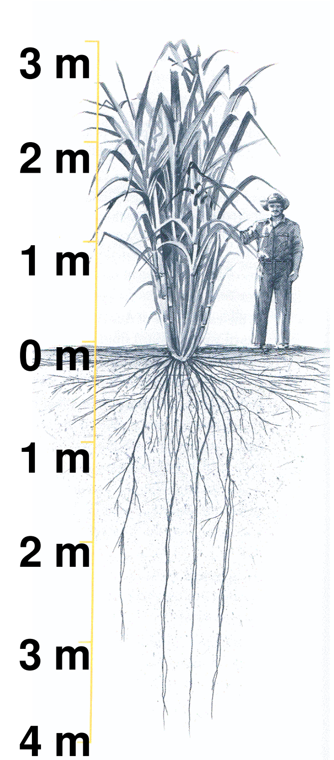
Sugarcane Etanol as Energy Source in Brazil

Sugarcane is the main source of bioenergy in Brazil



Sugarcane has been cultivated in Brazil since 1532 as sugar was one of the first commodities exported to Europe by the Portuguese settlers

Sugarcane Etanol as Energy Source in Brazil

Developing Ethanol as a Large Scale Bioenergy Source in Brazil

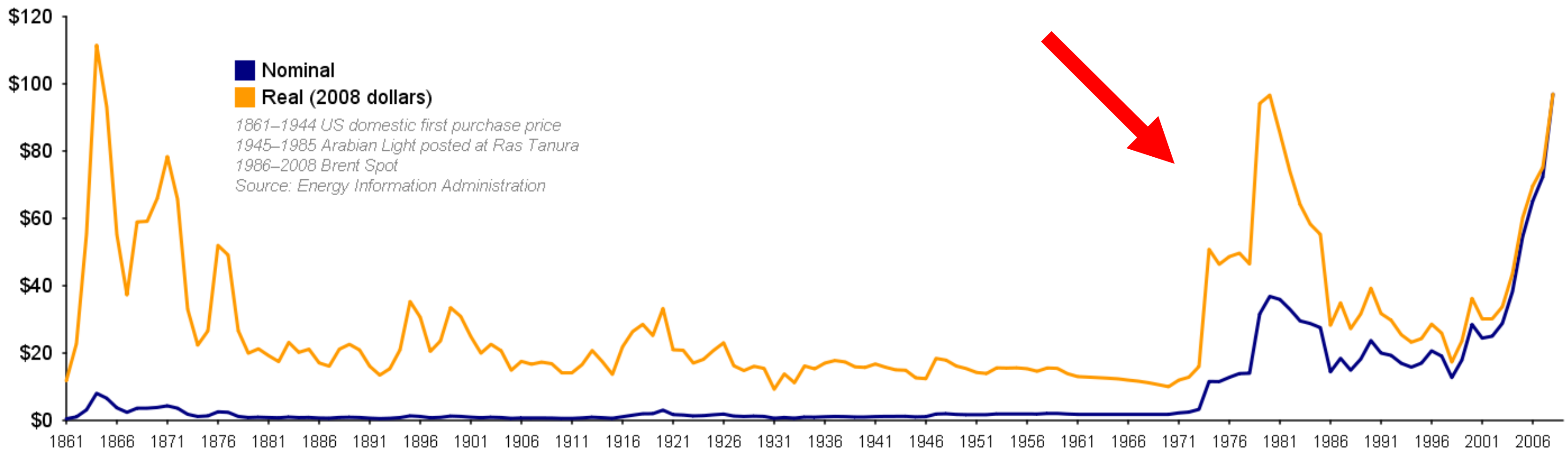
Brazil has been experimenting with sugarcane ethanol as an auto fuel since the beginning of last century

First Brazilian car fuelled by a blend of ethanol and gasoline - 1925

Sugarcane Etanol as Energy Source in Brazil

Developing Ethanol as a Large Scale Bioenergy Source in Brazil

Key driver was the energy crisis of 1973/1974 - huge increase in oil import costs



Graph of oil prices from 1861–2007, showing a sharp increase in 1973/1974, and again during the 1979 energy crisis. The orange line is adjusted for inflation.

Source: Energy Information Administration
http://upload.wikimedia.org/wikipedia/commons/8/87/Oil_Prices_1861_2007.svg

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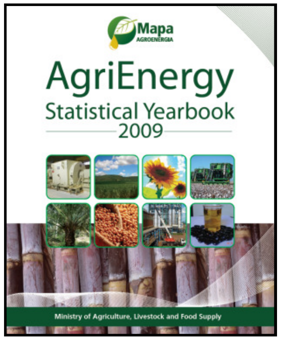
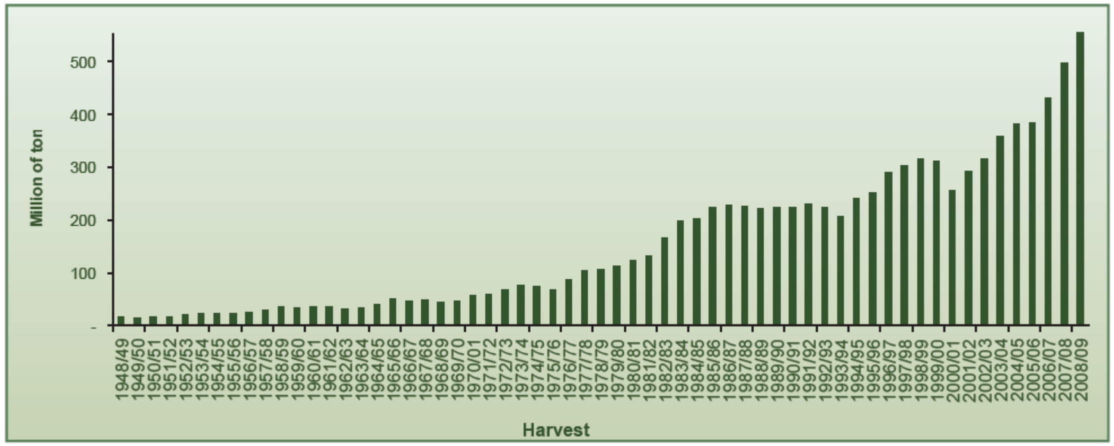
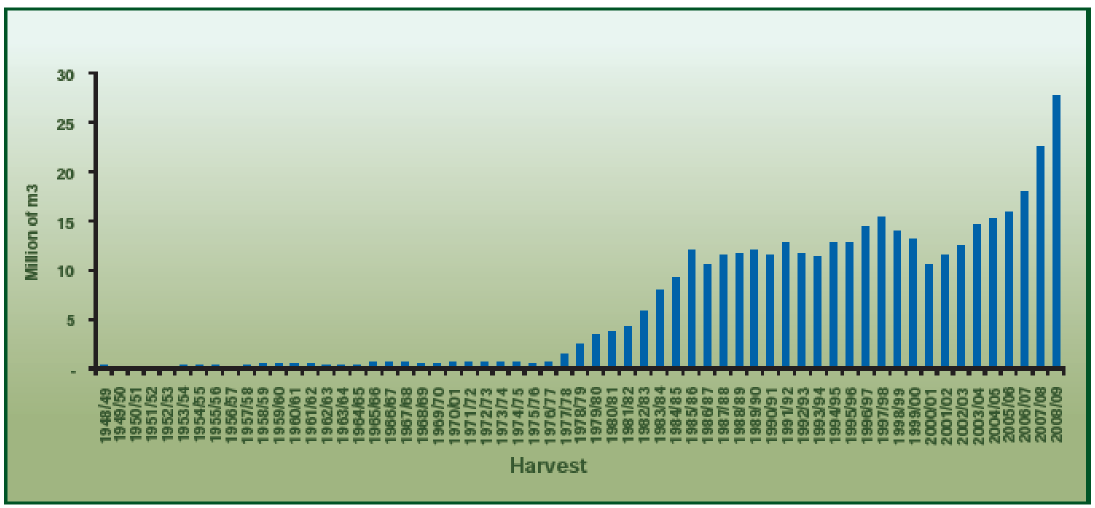
Sugarcane Etanol as Energy Source in Brazil



Lookback review of the Brazilian sucarcane production.

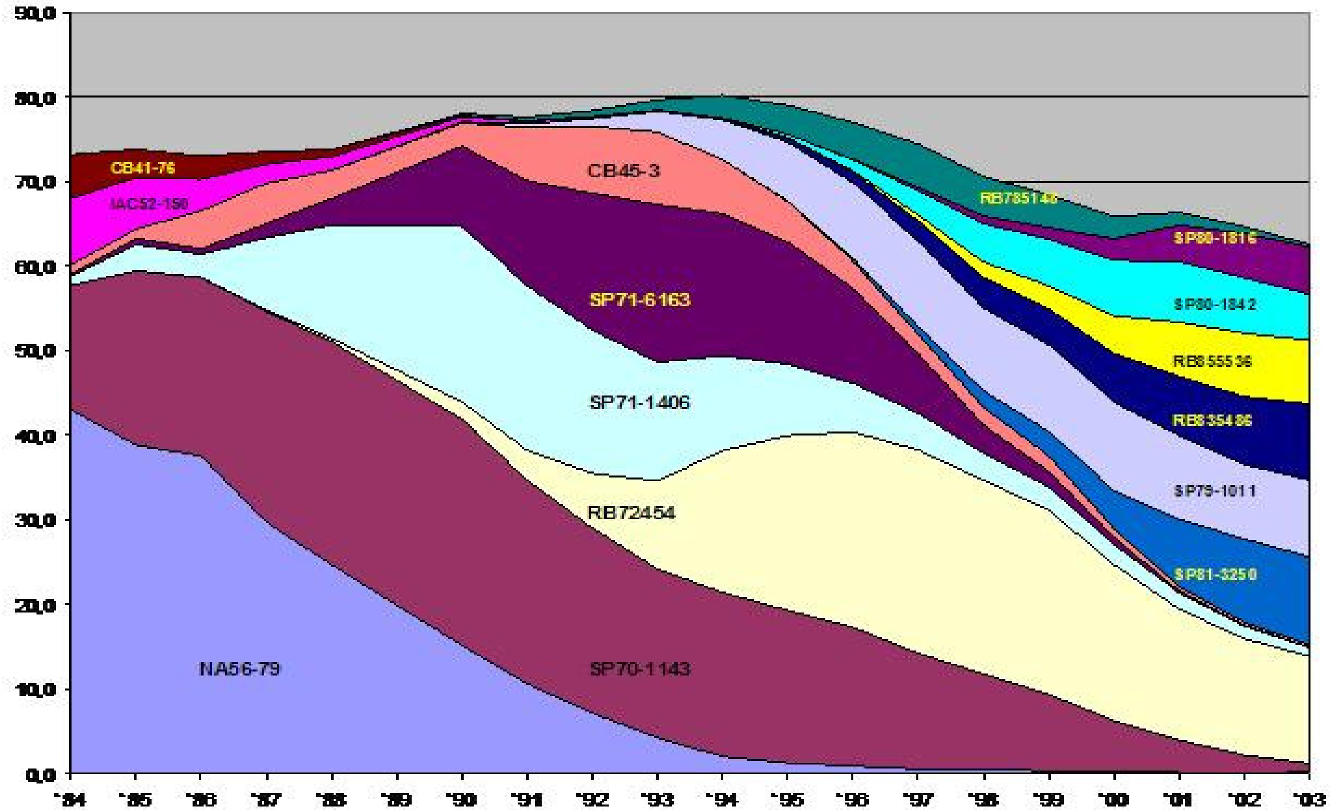


Ethanol production in Brazil.



Sugarcane Etanol as Energy Source in Brazil

R&D: Increasing number of Sugarcane varieties used in Brazil



1984 1994 2003

Developed by 3 research organizations
- CTC
- Ridesa
- IAC

Plus private companies
- Alellyx
- Canaviallis

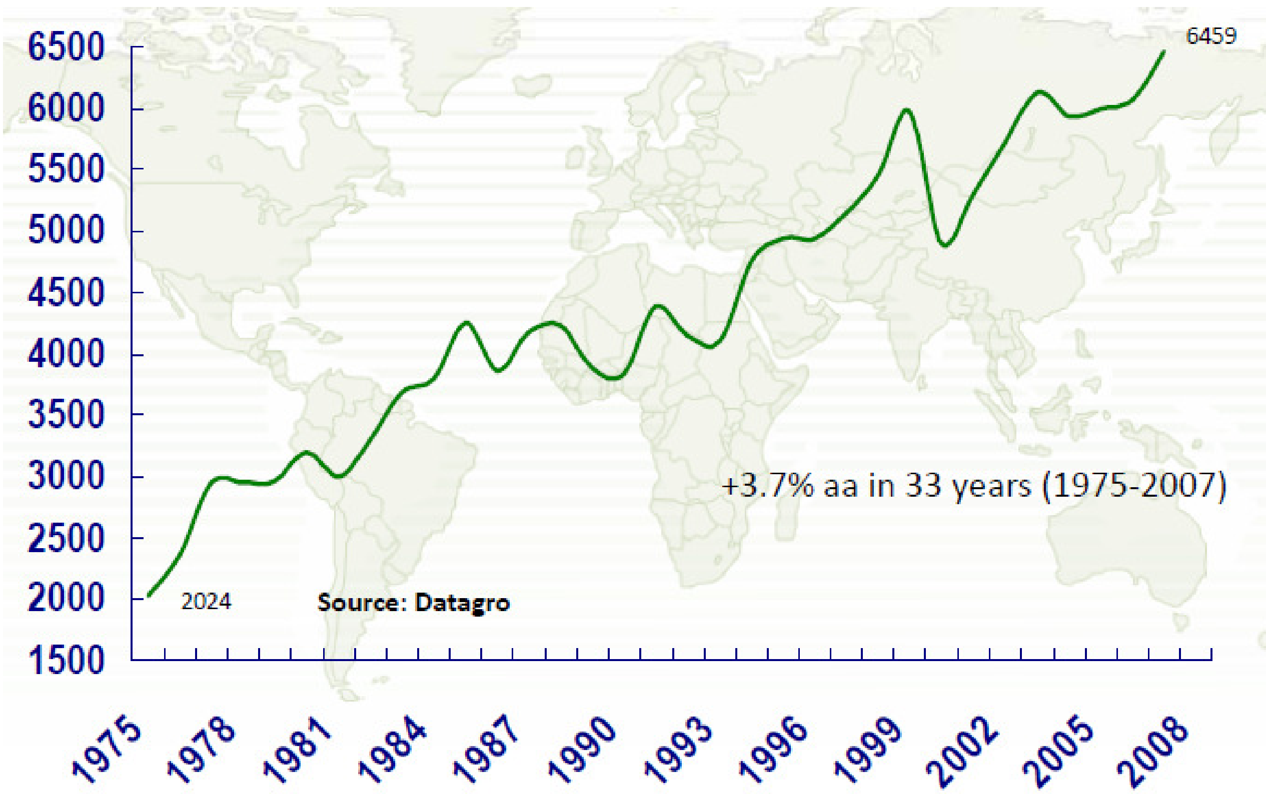
# of Varieties Developed = 550 # of Varieties Released since 1995 = 51

Source: Macedo & Nogueira, 2004; Queiroz, 2009; Brito Cruz, 2009

Sugarcane Etanol as Energy Source in Brazil

The Evolution of the Brazilian Ethanol Industry

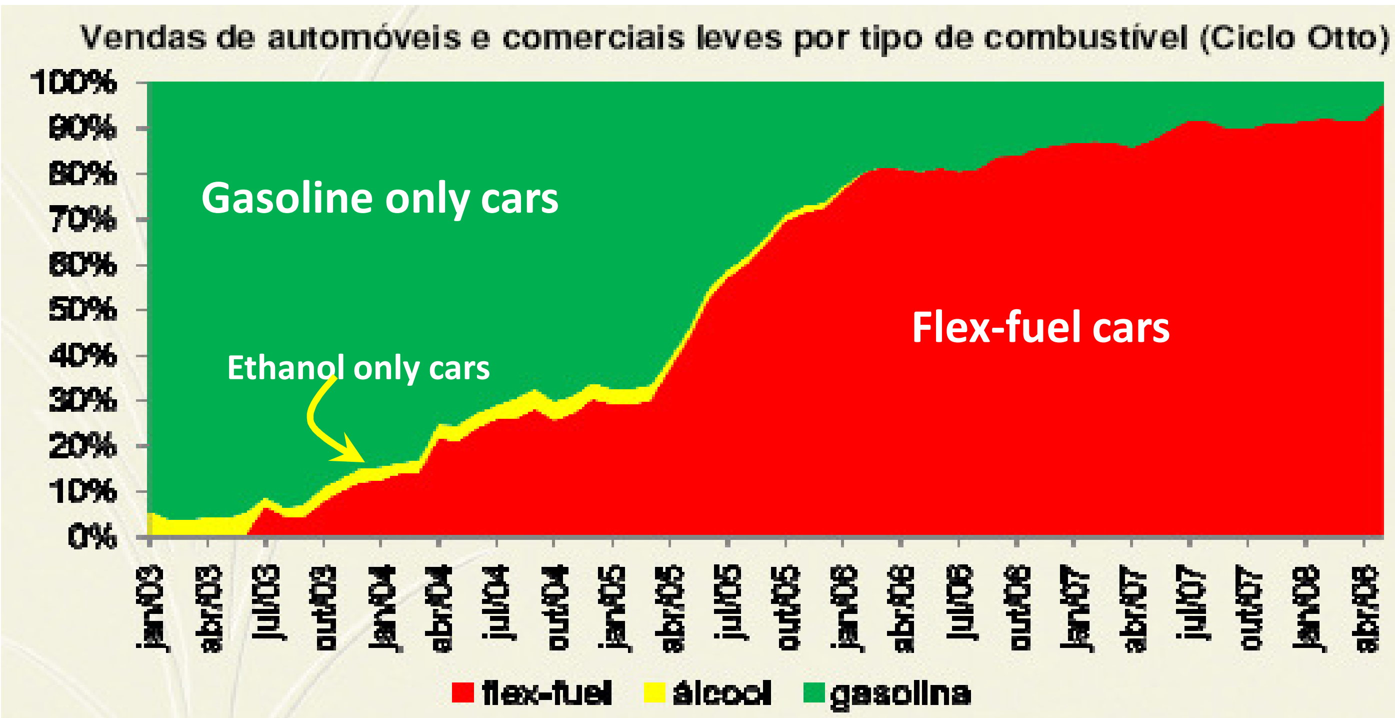
R&D - Evolution of agro industrial yield – liters of hydrous ethanol equivalent per ha



Fom Nastari, 2009

Sugarcane Etanol as Energy Source in Brazil

More than 95% of cars sold in Brazil are Flex-Fuel

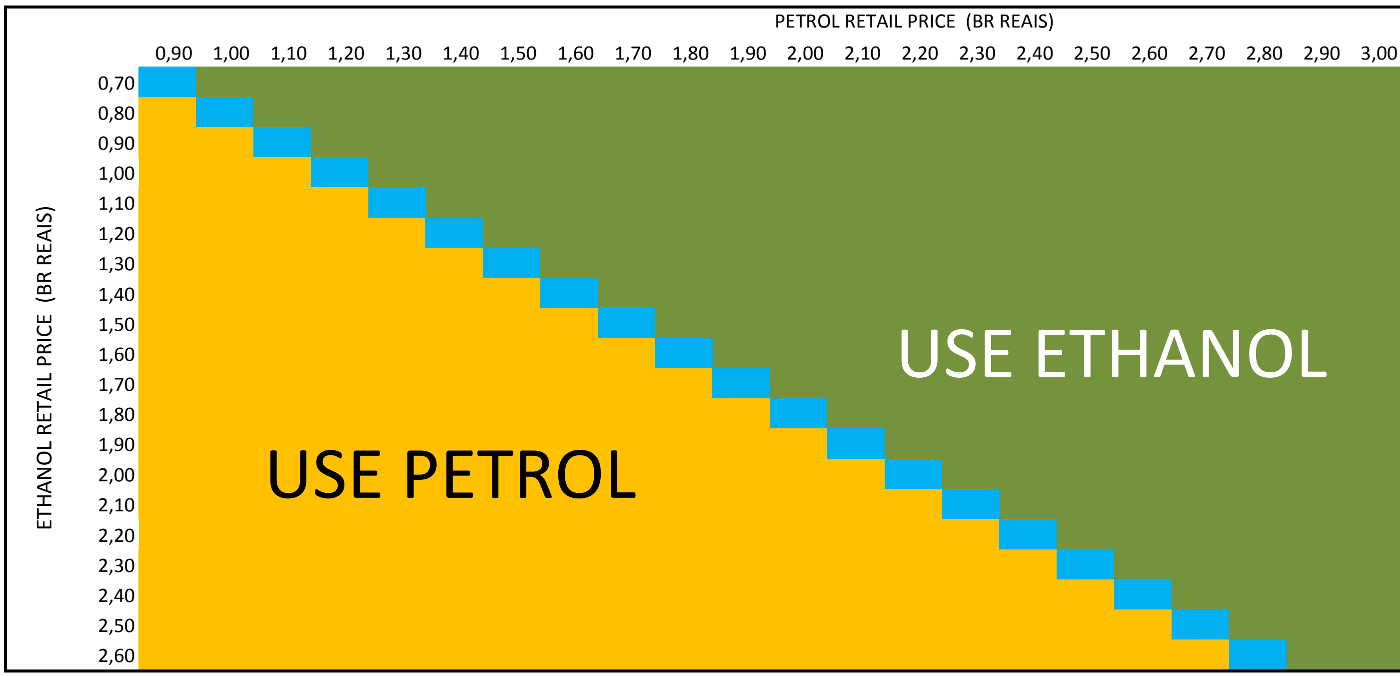


Source: ANFAVEA and UNICA, 2008

Sugarcane Etanol as Energy Source in Brazil

The Evolution of Logistics and Distribution

Brazil has 33,000 gas + ethanol stations (out of 36,000)



Source: Amatucci & Spers, 2008

Consumer choice: decision table to be used in the petrol station.
Source: based in a GM table distributed to flex car owners.

Sugarcane Etanol as Energy Source in Brazil

Ethanol in aircraft engines

Embraer Ipanema: a hydrated ethanol agricultural plane.

Hydrated ethanol is commonly used as a fuel for aircraft in the Brazilian country side, confirming the appropriateness and performance of such fuel in alternative engines. Since 2005, Embraer, the Brazilian aircraft company, has manufactured the Ipanema, an agricultural aircraft specially designed and licensed to use hydrated ethanol. Embrarer supplies kits for modifying gasoline engines to run on ethanol and it is currently developing flex-fuel systems for aircraft engines, aiming at meeting the requirements of small and agricultural piston engine aircraft. Currently, a fleet totaling 12,000 aircraft have ethanol engines [Scientific American Brazil (2006)]. The use of hydrated ethanol permits operational economies that reduce fuel costs per kilometer by 40% and increase engine power by 5% [Neiva Embraer (2008)]. This has encouraged the establishment of companies specialized in converting small aircraft to use this biofuel [Aeroálcool (2008)]. Several tests have been conducted on ethanol aircraft engines in the United States since 1980. In 1989 the Federal Aviation Authority (FAA) certified the first ethanol aircraft engine, the Lycoming IO-540 injected fuel. In subsequent years, the FAA certified the Lycoming O-235 carbureted engine and two aircraft, the Cessna 152 and the Piper Pawnee agricultural aircraft for using anhydrous ethanol with 5% gasoline (E95) [BIAS (2006)].

Sugarcane-based bioethanol : energy for sustainable development / coordination BNDES and CGEE – Rio de Janeiro : BNDES, 2008.

HONDA BEGINS SALES OF FLEX FUEL MOTORCYCLE

23 MARCH 2009

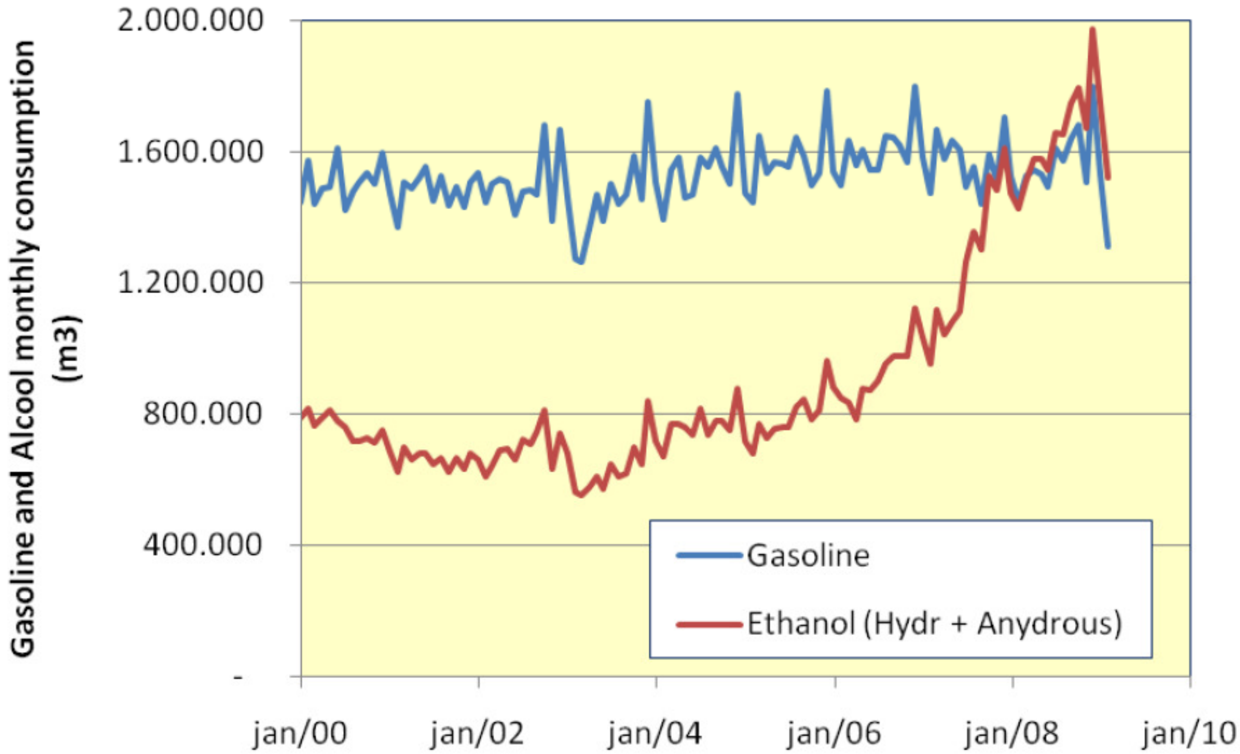
Honda Begins Sales of Flex Fuel Motorcycle CG150 TITAN MIX in Brazil

Source: http://www.metropolismotorcycles.com/cgi-bin/mm_news.pl?id=166

Sugarcane Etanol as Energy Source in Brazil

\`Gasoline is Becoming the Alternative Fuel in Brazil\`

Changes in Ethanol and Gasoline use in Brazil



Source: ANP, 2009 and Brito Cruz, 2009

Sugarcane Bagasse as Energy Source in Brazil

Energy efficiency of Sugarcane

Innovative co-generation plants produce energy from sugar cane waste - completely carbon-neutral.

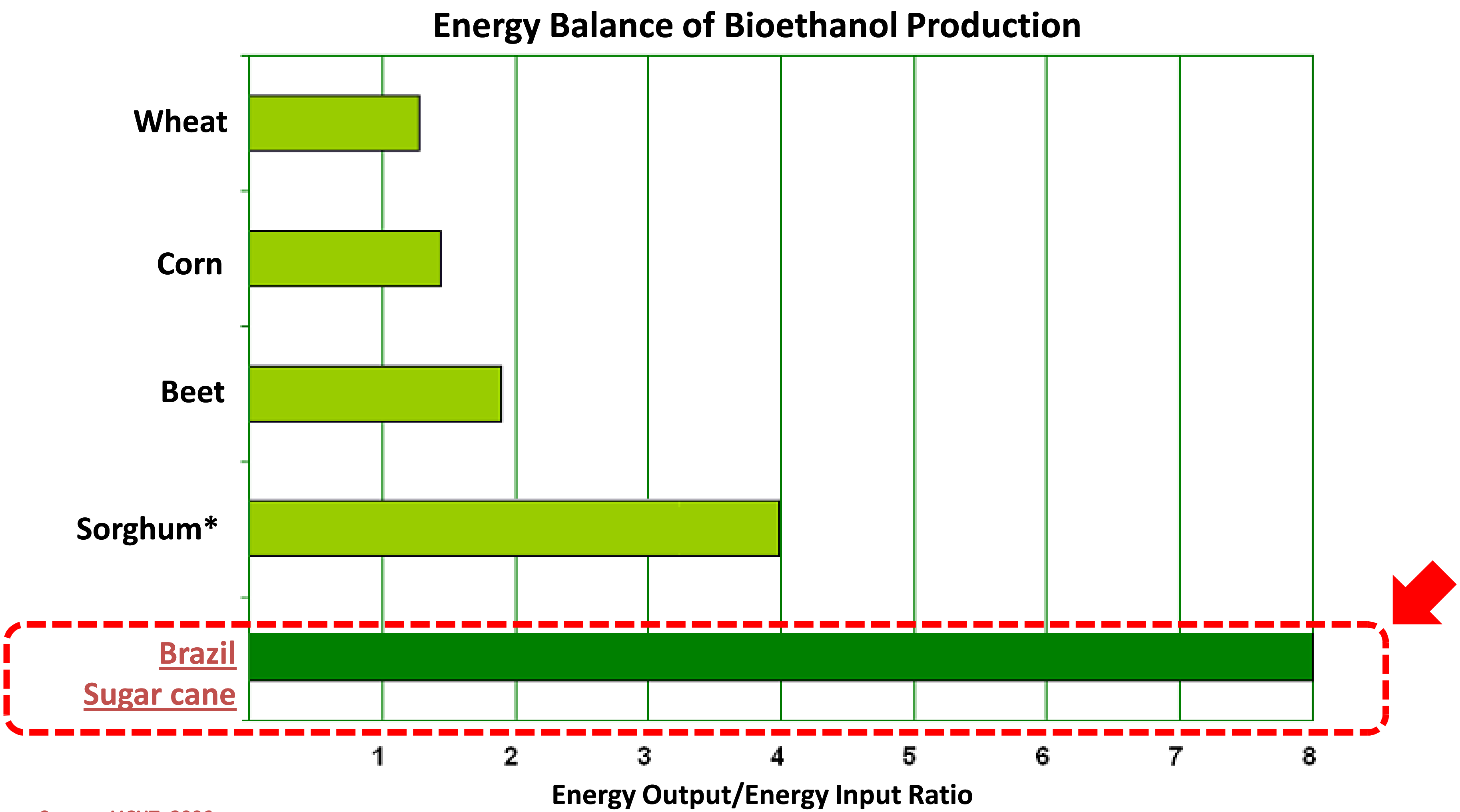
http://lanxess.com/uploads/tx_lxsmatrix/CoGen-Infographic_gr.JPG

Sugarcane Bagasse as Energy Source in Brazil

Mills and distilleries also generate electric and mechanical power. Equivalent to 3% of the electric power consumed in the Brazil.

For every additional 100 million tons of sugar-cane, 12.6 million tons of CO_2 equivalent worth of emissions could be avoided using ethanol, the bagasse and the additional electric power surplus.

Sustainability of Sugarcane as Energy Source in Brazil

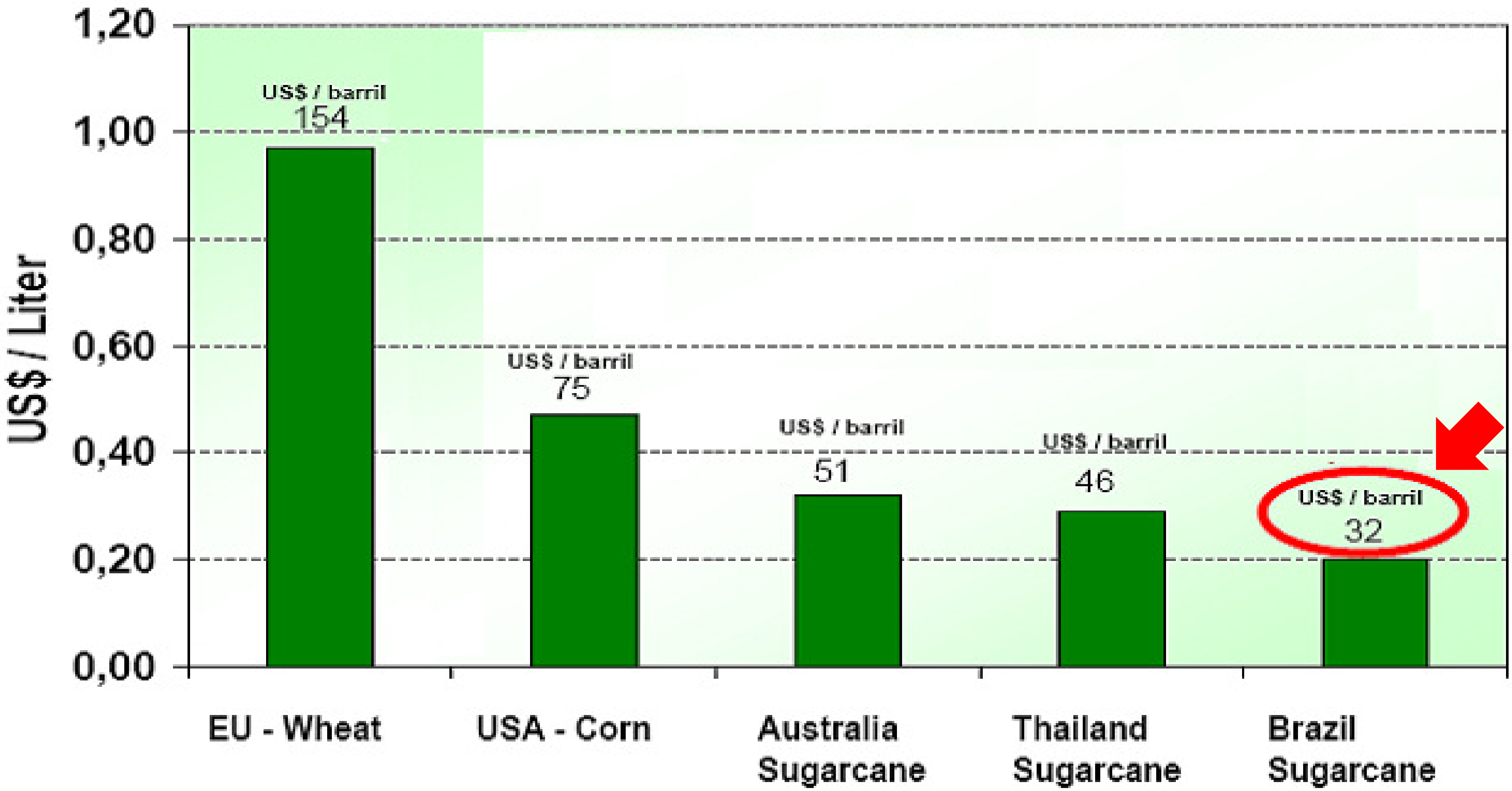


Source: LICHT, 2006.

* Source: WORLD WATCH INSTITUTE.

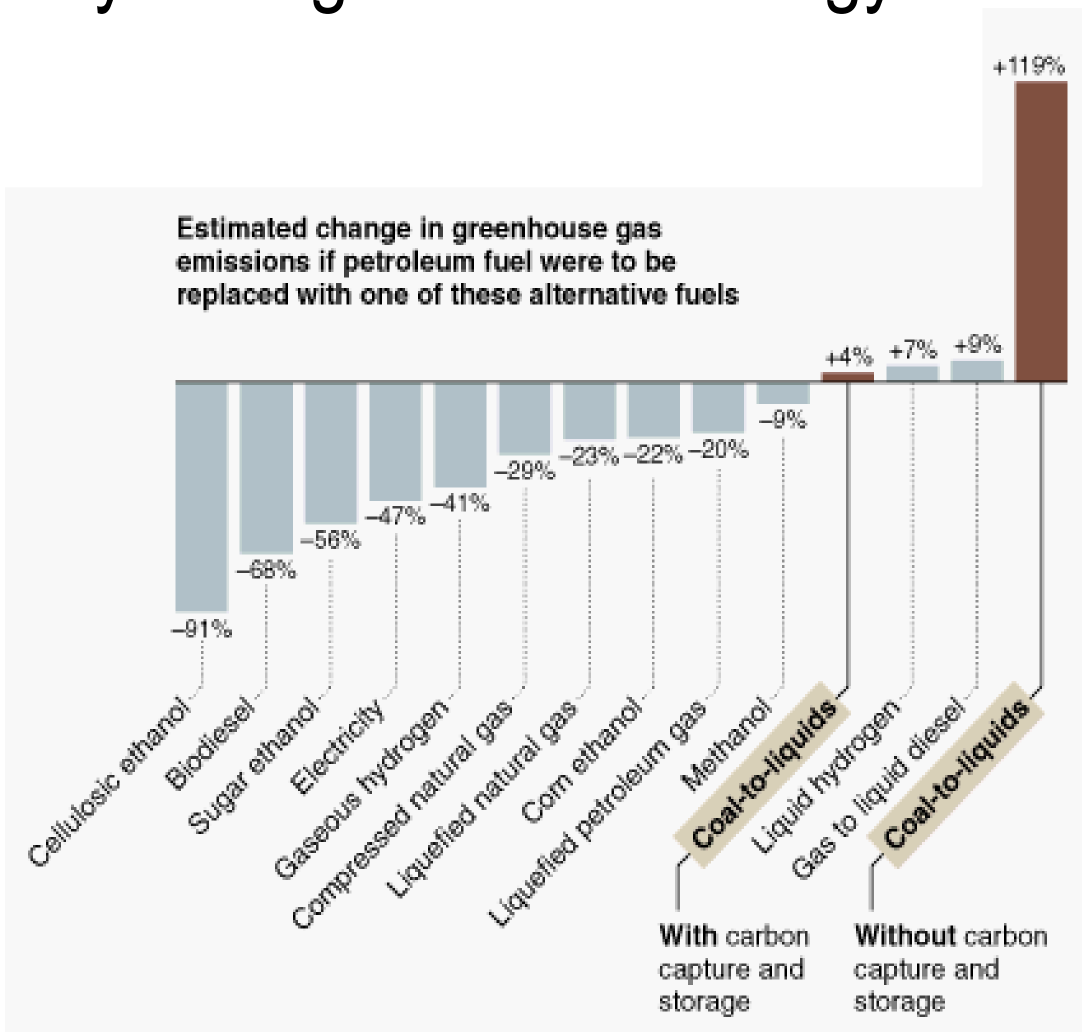
Sustainability of Sugarcane as Energy Source in Brazil

Cost of Bioethanol Production



Source: DATAGRO, 2006.

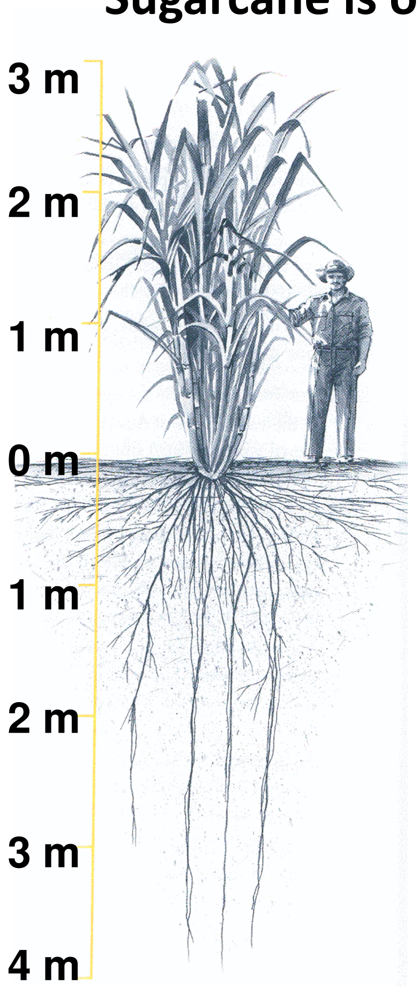
Sustainability of Sugarcane as Energy Source in Brazil



Source - http://thinkprogress.org/2007/05/29/coal-warming/

Sustainability of Sugarcane Etanol

Sugarcane is one of the most sustainable energy factories in the world



Productivity

Favorable energy balance

Significant carbon emission reduction

Competitive fuel for consumers

Clear contribution to energy security

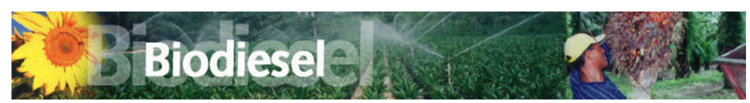
Other Biofuels in Brazil - Biodiesel

% Ethanol in Gasoline (gasohol)

1977: 4.5%
1979: 15%
1981: 20%
1985: 22%
1998: 24%
1999: 20 to 24%

SINCE 2002
20% to 25%

- ✓ **Alcohol as fuel for light applications (cars, vans);**
- ✓ **Oil derived fuels (biodiesel) for heavy duty applications (passenger and cargo transportation, industrial uses, electricity generation).**



- ✓ **Mimic ethanol to gasoline addition policies.**

Public Policies to support development and use

2002 Ministry of Science and Technology initiated ProBiodiesel

2004 National Program of Biodiesel Production and Use (PNPB)

2005 First biodiesel processing plant was established in Minas Gerais State

- **Law 11.097/2005: Establishes minimum percentages to mix biodiesel to diesel, defines criteria to monitor the introduction of this new fuel into the market.**

2005 to 2007	2008 to 2012	From 2013 on
2% Authorized	**3%** Mandatory	**5%** Mandatory

Public Policies to support development and use

Figure 7. Biodiesel sources according to Brazilian regions.

Biodiesel production in 2008:
1,166 billion liters

Law 11.097/2005:

2005 to 2007

(2% permitted) => 0 – 840 million liters

2008 to 2012

(3% mandatory)

(5% permitted) => 1,3 – 2,5 billion liters

From 2013 on

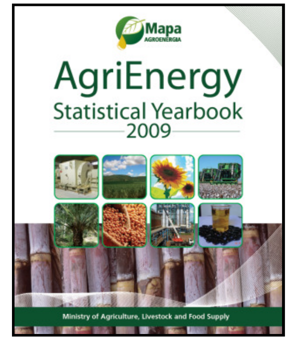
(5% mandatory) => 2,5 billion liters

Public Policies to support development and use

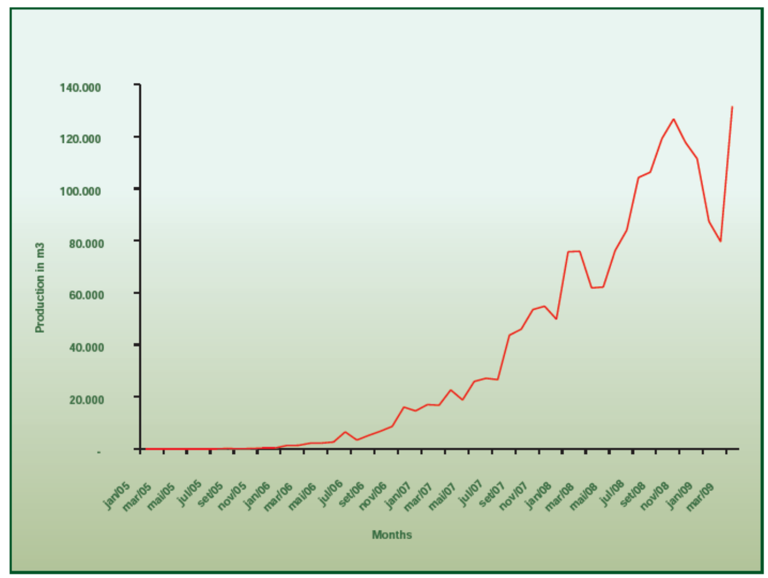
Biodiesel production in Brazil, in m^3.

MONTHS	2005	2006	2007	2008	2009
JANUARY	2005	2006	2007	2008	2009
FEBRUARY	0	1.075	17.109	76.784	87.394
MARCH	0	1.043	16.933	77.085	79.658
APRIL	8	1.725	22.637	63.680	131.700
MAY	13	1.786	18.773	64.350	
JUNE	26	2.578	26.005	75.999	
JULY	23	6.490	27.158	102.767	
AUGUST	7	3.331	26.718	107.786	
SEPTEMBER	57	5.102	43.959	109.534	
OCTOBER	2	6.735	46.013	132.258	
NOVEMBER	34	8.581	53.609	126.817	
DECEMBER	281	16.025	56.401	117.803	
TOTAL YEAR	285	14.531	49.016	111.515	
TOTAL ANO	736	69.002	404.329	1.166.379	298.752

Source: ANP



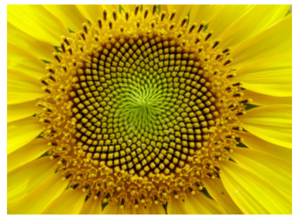
Monthly biodiesel production in Brazil, in m^3.



Source: ANP

Alternative Biofuels in Brazil - Biodiesel -






	Jatropha	Castor	Sunflower	Soybeans	Oil Palm	Cotton
Average Agricultural Productivity (kg/ha)	5.000*	1.500	1.500	3.000	20.000	3.000
Oil Content (%)	25	47	42	18	20	15
Productivity of Vegetable Oil (kg/ha)	1250	705	630	540	4.000	450

Brazil has over 100 potential oil plants in its biodiversity that can be developed as oil crops for biodiesel production

Source: Biofuels for Transportation - Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century World Watch 2006, http://www.worldwatch.org/system/files/EBF008_1.pdf

Challenge: developing new oil sources

CROP	OIL SOURCE	OIL CONTENT	BRAZILIAN HARVEST	BRAZILIAN YIELD
		%	mo y^{-1}	t oil ha^{-1}
African Palm (*Elaeis guineensis*)	Seed	22.0	12	3.0 – 6.0
Avocado (*Persea americana*)	Fruit	7.0 – 35.0	12	1.3 – 5.0
Babassu (*Attalea speciosa*)	Seed	66.0	12	0.1 – 0.3
Castor bean (*Ricinus communis*)	Grain	45.0 – 48.0	3	0.5 – 1.0
Coconut (*Cocos nucifera*)	Fruit	55.0 – 60.0	12	1.3 – 1.9
Colza/Canola (*Brassica* spp.)	Grain	40.0 – 48.0	3	0.5 – 0.9
Cotton (*Gossypium hirsutum*)	Grain	15.0	3	0.1 – 0.2
Peanut (*Arachis hypogaea*)	Grain	40.0 – 43.0	3	0.6 – 0.8
Soybean (*Glycine max*)	Grain	18.0	3	0.2 – 0.6
Sunflower (*Helianthus annuus*)	Grain	38.0 – 48.0	3	0.5 – 1.9

Source: Nass et al. (2007)

Species under investigation for biodiesel production in Brazil

Acrocomia aculeata (macauba palm)	***Licania rigida*** (oiticica)
Astrocaryum murumuru (murumuru)	***Mauritia flexuosa*** (buriti palm)
Astrocaryum vulgare (tucumã)	***Maximiliana maripa*** (inaja palm)
Attalea geraensis (indaiá-rateiro)	***Oenocarpus bacaba*** (bacaba-do-azeite)
Attalea humillis (pindoba)	***Oenocarpus bataua*** (patauá)
Attalea oleifera (andaiá)	***Oenocarpus distichus*** (bacaba-de-leque)
Attalea phalerata (uricuri)	***Paraqueiba paraensis*** (mari)
Caryocar brasiliense (pequi)	***Sesamum indicum*** (benneseed)
Cucumis melo (melon)	***Theobroma grandiflorum*** (cupuassu)
Jatropha curcas (pinhão-manso)	***Trithrinax brasiliensis*** (carandaí)
Joannesia princeps (cutieira)	***Zea mays*** (corn)

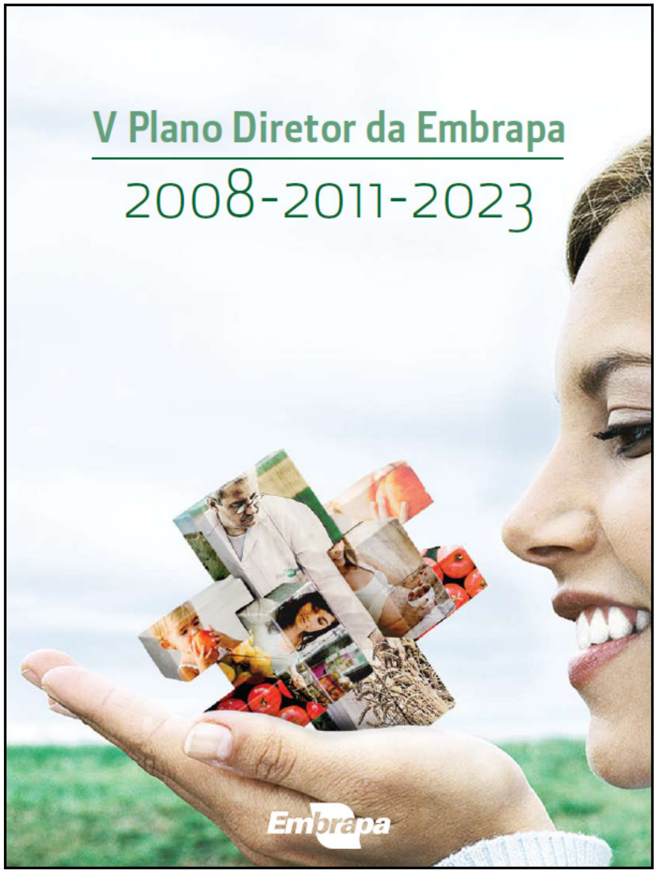
Source: Nass et al. (2007)

Research & Development Programs

Labex Korea

Research & Development Programs

Embrapa´s Strategic Objectives



SO1:
Competitiveness & Sustainability of Brazilian Agribusiness

SO2: Technological competitiveness in Agroenergy and Biofuels

SO3:
Sustainable Use of Biomes and Productive Integration of Brazilian Regions

SO4:
Biodiversity Prospecting for the Development of Differentiated and Value-added Products

SO5:
Advances in the Knowledge Frontier and Emergent Technologies

Research & Development - Agroenergy and Biofuels

• Development of new technologies for energy production (ethanol from cellulose, products of bio-refinery, hydrogen)

- Enzymatic pathway for ethanol from lignocellulosic materials
- Enzymes, fungi, bacteria and catalysts with impact in energy production
- R&D focusing the concept of bio-refinery

•Development of technologies for economical use of by-products and residues

- Economical use of meals, glycerin & by-products of biodiesel production
- Economical use of by-products from the charcoal industry for the production of biofertilizers and biopesticides
- Economical use of residues and by-products from the 1st and 2nd generation ethanol production processes

Research & Development - Agroenergy and Biofuels

Longer-term objectives

• Development of novel production systems and raw materials with superior characteristics for the production of energy.

• Zoning and evaluation of environmental, economic and social impacts of agroenergy souces for the identification of areas for competitive and sustainable production.

• Development of technologies and production systems aiming at using degraded areas for the production of bioenergy.

Research & Development - Agroenergy and Biofuels

<u>Embrapa Agroenergy</u> :

Laboratory of Energy Biology

Laboratory of Energetic Feedstock Processing

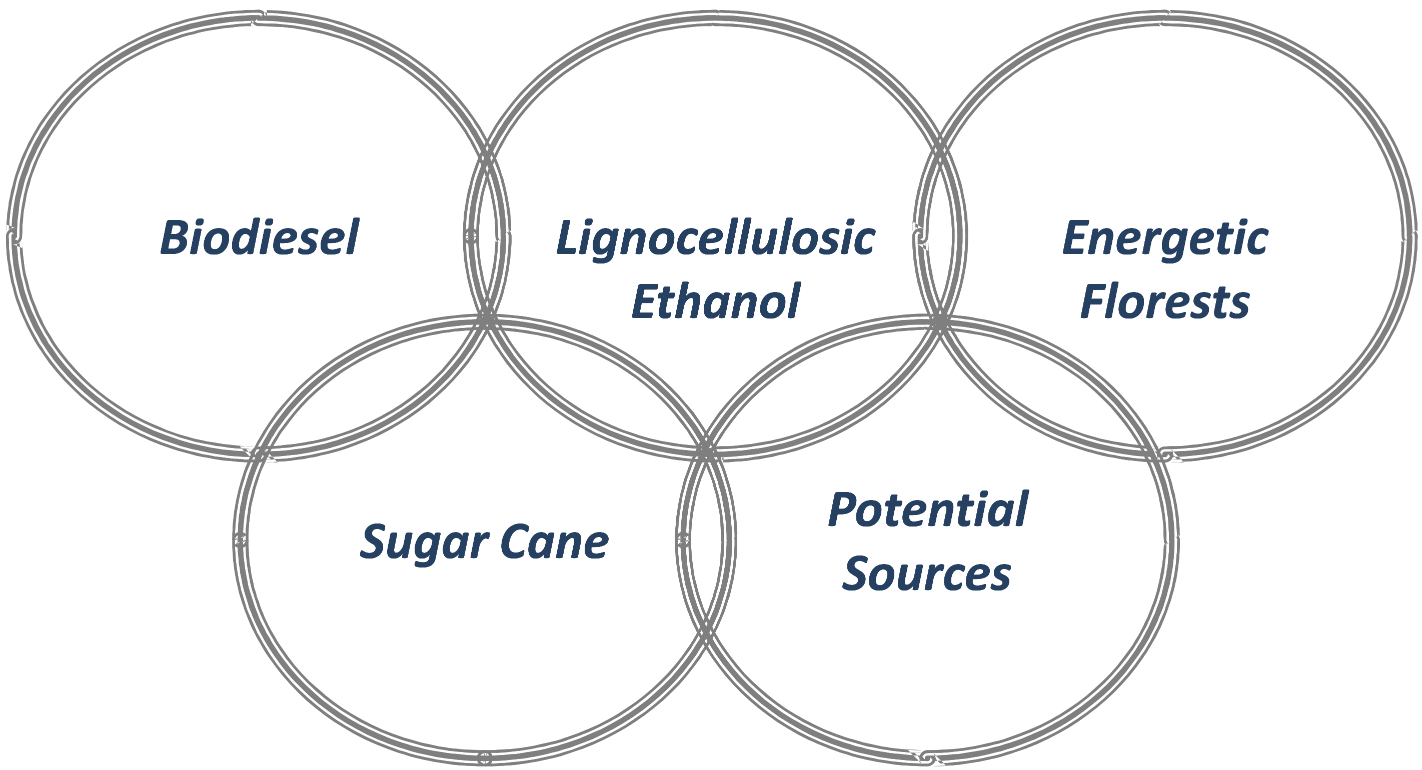
Laboratory of Co-products and Residues Processing

Laboratory of Knowledge Management in Agroenergy

Source: Embrapa Agroenergy

Research & Development - Agroenergy and Biofuels

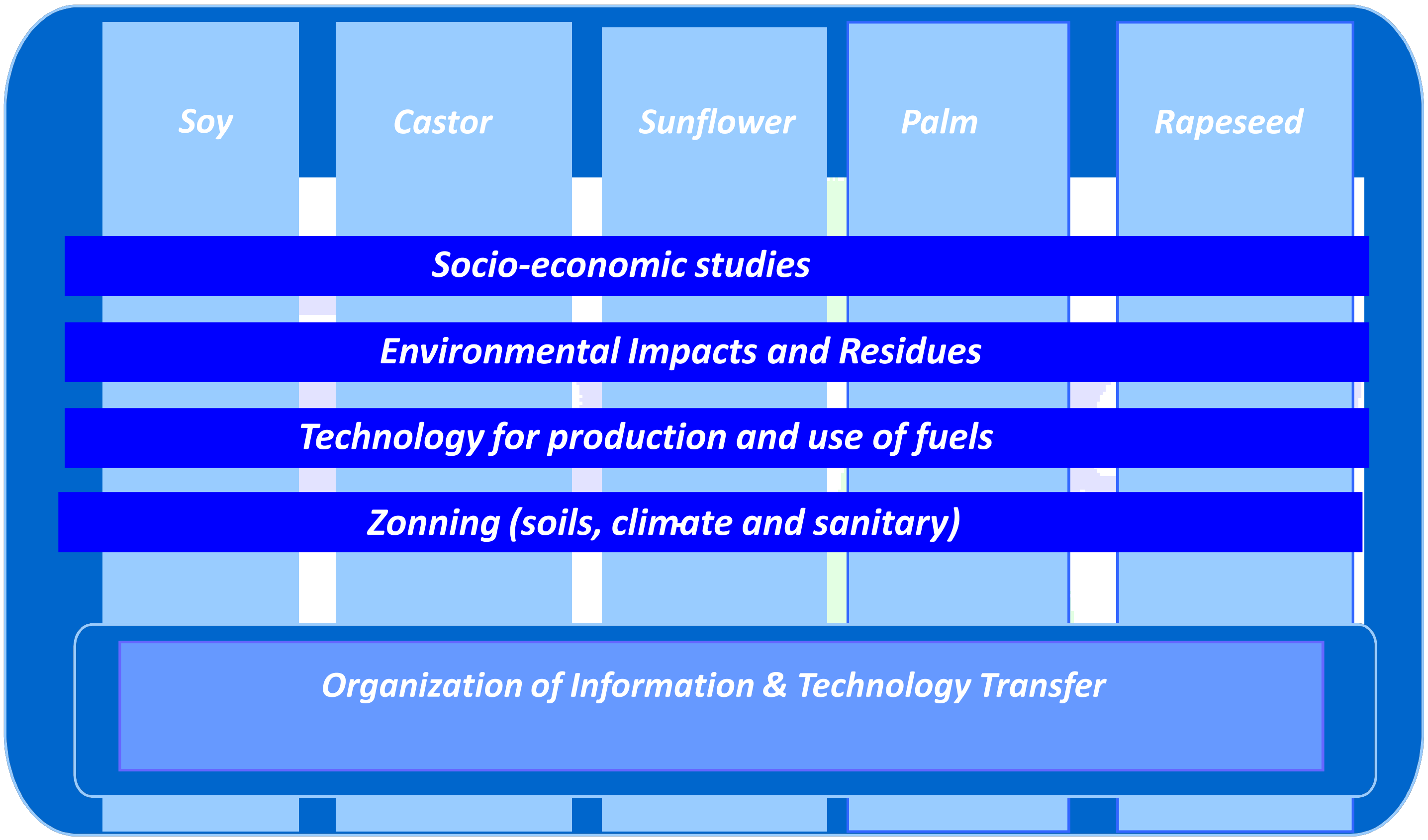
Embrapa's R&D Platforms in Agroenergy



Source: Embrapa Agroenergy

Research & Development - Agroenergy and Biofuels

➢ ***Biodiesel Platform***

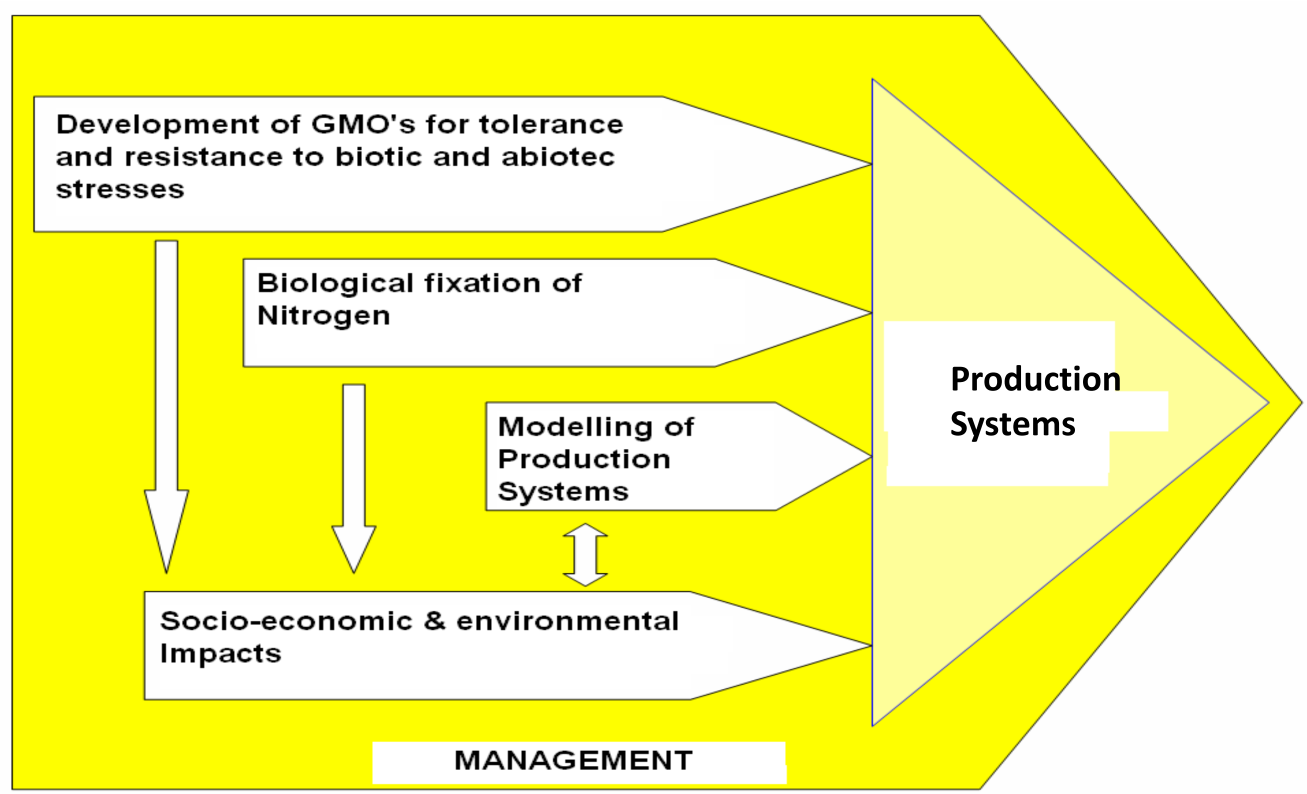


NETWORK: 160 scientists (15 Embrapa R&D Centers, 9 Universities, 5 R&D Institutes, ...)

Source: Embrapa Agroenergy

Research & Development - Agroenergy and Biofuels

- ***Sugar Cane***

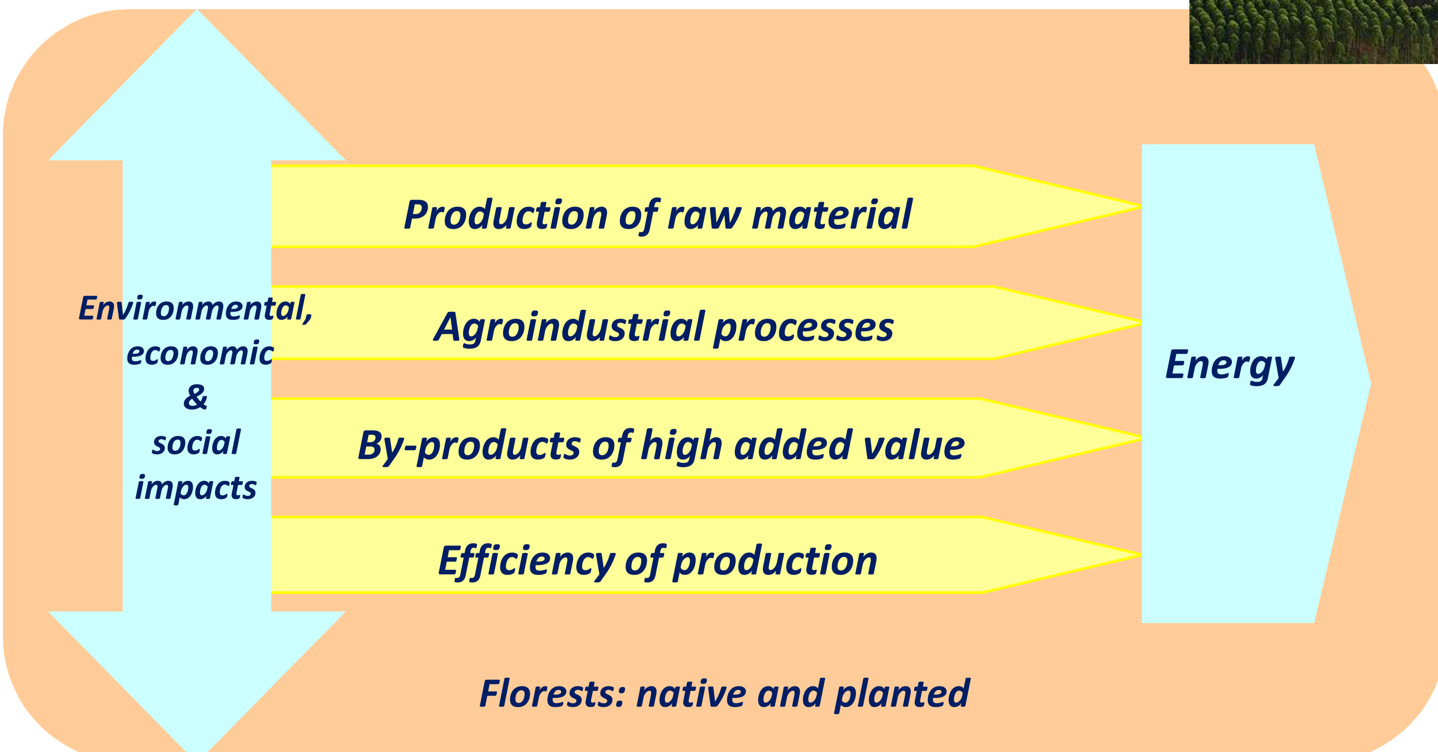


NETWORK: 100 scientists (8 Embrapa R&D Centers, 2 Universities, 1 R&D Institute, ...)

Source: Embrapa Agroenergy

Research & Development - Agroenergy and Biofuels

- ***Energetic Forests***



NETWORK: ±130 scientists (17 Embrapa R&D Centers, 15 Universities, 14 R&D Institutes, ...)

Source: Embrapa Agroenergy

Research & Development - Agroenergy and Biofuels

- ***Potential agroenergy sources***

Domestication and production systems for potencial alternative raw materials for biodiesel production

Physico-chemical characterization, processing and new uses

Energy balance & Carbon sequestration

Environmental, social and economic impacts

Management

Production Systems
Current and future demands defined

NETWORK: ±170 scientists (20 Embrapa R&D Centers, 9 Universities, 1 R&D Institute, ...)

Source: Embrapa Agroenergy

Research & Development - Agroenergy and Biofuels

- ***Ethanol from lignocellulosic materials***

Characterization & selection of lignocellulosic biomass

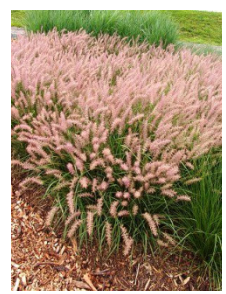
Prospection & selection of microorganisms

Molecular genetics of gramineae & microorganisms

Conversion processes

Alternative sources of biomass & technological routes for the sustainable production of ethanol from lignocellulosic materials



NETWORK: ±75 scientists (14 Embrapa R&D Centers, 7 Universities, 1 R&D Institute, ...)

Source: Embrapa Agroenergy

Research & Development - Agroenergy and Biofuels

Cellulosic Ethanol from Sugarcane

- A option for bagasse, tops and leaves.
- Sugar mill is already a logistics operation for transport of low value product.
- Cost of collection in Brazil is low – cane produced near plants :
  - US$ 6/ton for tops and leaves.
  - Zero cost for bagasse.
- Cost of collection in Northern hemisphere countries estimated at US$ 15 to 60/ton.
- Cellulosic ethanol will be more competitive from sugar cane bagasse, & tops and leaves.

From Nastari, 2009

Embrapa

Ministry of Science and Technology Platform

Bioethanol
Scientific-Technological & Production Challenges

1 • Alcohol chemistry / Biorefineries

2 • Development of agrobiotechnology (enzymes)

3 • 2nd Generation Biofuels: lignocellulose (enzymatic hydrolysis) and gasification

4 • Development and production of new cultivars of sugar cane

5 • New fertilizers and nutrients for agroenergy crops

Source: Ministry of Science & Technology, 2007.

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institutos nacionais
de ciência e tecnologia

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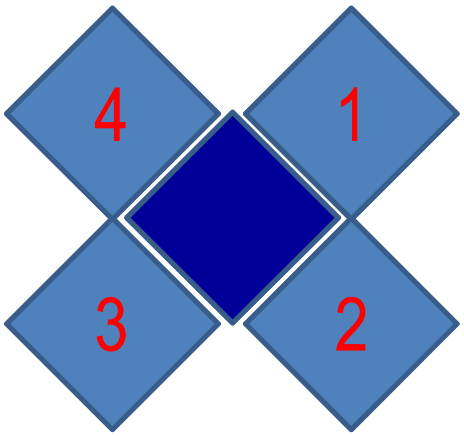
Ministry of Science and Technology Platform

Biodiesel
Scientific-Technological & Production Challenges



1 • Technology of the ethylic production route

2 • Adding-value to by-products

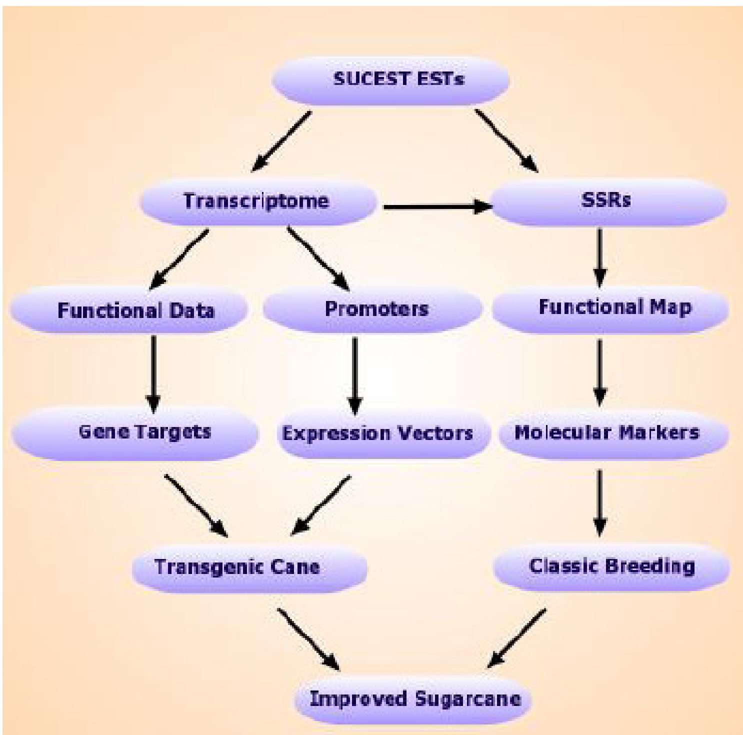
3 • Development and production of improved varieties of oil plants and raw materials

4 • Validation of use in vehicle and stationary engines

Source: Ministry of Science & Technology, 2007.

FAPESP – São Paulo Foundation for Science and Technology

FAPESP: SUCEST Program



- Started 1999
- Molecular Biology tools for improving sugarcane
- Science and Technology of sugarcane
  - Articles, thesis and patents
  - Human resources

Source: Brito Cruz, 2008

FAPESP – São Paulo Foundation for Science and Technology

SUCEST Project
FAPESP, 1999 - 2004

Genome Research

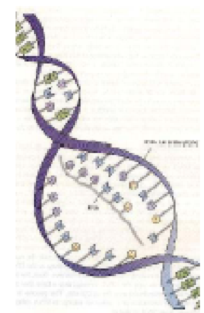
13:2725–2735 ©2003 by Cold Spring Harbor Laboratory Press ISSN 1088-9051/03 $5.00; www.genome.org

Analysis and Functional Annotation of an Expressed Sequence Tag Collection for Tropical Crop Sugarcane

André L. Vettore,[1,24] Felipe R. da Silva,[1,25] Edson L. Kemper,[1,26] Glaucia M. Souza,[3] Aline M. da Silva,[3] Maria Inês T. Ferro,[6] Flavio Henrique-Silva,[8] Éder A. Giglioti,[9] Manoel V.F. Lemos,[7] Luiz L. Coutinho,[10] Marina P. Nobrega,[11] Helaine Carrer,[10] Suzelei C. França,[12] Maurício Bacci Jr.,[13] Maria Helena S. Goldman,[14] Suely L. Gomes,[3] Luiz R. Nunes,[15] Luis E.A. Camargo,[10] Walter J. Siqueira,[16] Marie-Anne Van Sluys,[4] Otavio H. Thiemann,[17] Eiko E. Kuramae,[18] Roberto V. Santelli,[3] Celso L. Marino,[19] Maria L.P.N. Targon,[20] Jesus A. Ferro,[6,27] Henrique C.S. Silveira,[8] Danyelle C. Marini,[9] Eliana G.M. Lemos,[6] Claudia B. Monteiro-Vitorello,[10] José H.M. Tambor,[11] Dirce M. Carraro,[10,24] Patrícia G. Roberto,[12] Vanderlei G. Martins,[21] Gustavo H. Goldman,[22] Regina C. de Oliveira,[15] Daniela Truffi,[10] Carlos A. Colombo,[16] Magdalena Rossi,[4] Paula G. de Araujo,[4] Susana A. Sculaccio,[17] Aline Angella,[18] Marleide M.A. Lima,[18] Vicente E. de Rosa Jr.,[18] Fábio Siviero,[3] Virginia E. Coscrato,[19] Marcos A. Machado,[20] Laurent Grivet,[23] Sonia M.Z. Di Mauro,[6] Francisco G. Nobrega,[11] Carlos F.M. Menck,[5] Marilia D.V. Braga,[2,28] Guilherme P. Telles,[2] Frank A.A. Cara,[2] Guilherme Pedrosa,[2] João Meidanis,[2] and Paulo Arruda[1,27,29]

50 labs

200 researchers



238000 ESTs

43000 Transcripts

Source: Brito Cruz, 2008

FAPESP's Research Program on Bioenergy (BIOEN): 5 Divisions

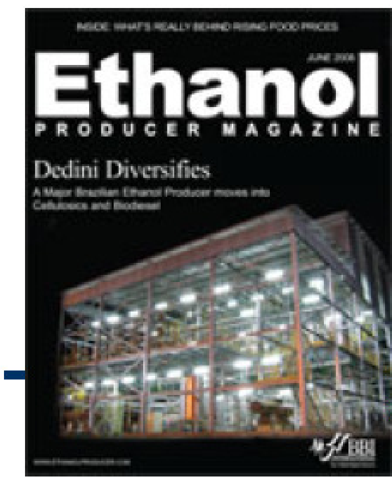
1. Improvements in the feedstock: building a better cane plant for energy
2. Production of Ethanol and other products: hydrolysis, pyrolisis, gasification, fermentation, distillation
3. New processes in alcohol-chemistry
4. Ethanol based engine and fuel cell developments
5. The Economics of Ethanol, Ethanol production and the environment, Social impacts, the new agriculture of food AND energy

Source: Brito Cruz, 2008

FAPESP – São Paulo Foundation for Science and Technology

Demonstration Plant for Acid Hydrolisis: FAPESP - Dedini

- Project started in 2002
- Dedini-Fapesp proprietary process
- Demonstration plant
  - 5,000 liters per day
  - Mixed with input for fermentation



Planta DHR

Source: Brito Cruz, 2008

Summary of Challenges and Opportunities

Ethanol

- ✓ Improve Agricultural and industrial processes (harvesting, waste mgmt...)
- ✓ Biotechnology to introduce new traits to sugarcane (resistance, drought, etc)
- ✓ Implement the agroecological zoning to open new areas in a sustainable way
- ✓ Develop technologies to promote symbiotic N fixation and alternative P
- ✓ New products and processes based on alcohol chemistry and improved use of sugarcane biomass

Biodiesel

- ✓ Evaluation of additional oil plant species
- ✓ Development of new varieties
- ✓ Development of new cropping systems
- ✓ Agroecological zoning of conventional and potential species
- ✓ Harvesting and processing systems for improved oil extraction and coproducts use
- ✓ Biotechnology to introduce new traits and to speed up the breeding process

Summary of Challenges and Opportunities

- ✓ **Technology - efficiency & sustainability** **(more with less area, water, energy,...)**
- ✓ **Implementing and perfecting the agroecological zoning**
- ✓ **Strategic Inteligence - market dynamics and trends - internal & external**
- ✓ **As a global market develops - Standards, certification and traceability**
- ✓ **Infrastruture and logistics**
- ✓ **Comunicação e information**
- ✓ **Capacity building**

Summary of Challenges and Opportunities

- ✓ Genetic resources, pre-breeding, breeding and development of improved feedstock for ethanol and biodiesel production
- ✓ Enzymes and microorganisms useful to convert biomass into sugars, ethanol and other value added products
- ✓ Improved bioprocess technologies to allow efficient conversion of lignocellulosic biomass into biofuels
- ✓ Industrial automation, improved fermentation processes – yeast breeding
- ✓ Genetically modified energy crops
- ✓ Applied nanotechnology

Challenges and Opportunities

APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Dec. 2005, p. 8132–8140 Vol. 71, No. 12
0099-2240/05/$08.00+0 doi:10.1128/AEM.71.12.8132–8140.2005

Construction of Engineered Bifunctional Enzymes and Their Overproduction in *Aspergillus niger* for Improved Enzymatic Tools To Degrade Agricultural By-Products

Anthony Levasseur,[1]* David Navarro,[1] Peter J. Punt,[2] Jean-Pierre Belaïch,[3,4] Marcel Asther,[1] and Eric Record[1]

UMR 1163 INRA de Biotechnologie des Champignons Filamenteux, IFR86-BAIM, Universités de Provence et de la Méditen ESIL, 163 Ave. de Luminy, Case Postale 925, 13288 Marseille Cedex 09, France[1]; Department of Microbiology, Quality of Zeist, The Netherlands[2]; Bioénergétique et Ingéniérie des Protéines, Centre National de la Recherche Scientifique, IBSM 13402 Marseille, France[3]; and Université de Provence, 3 Place Victor Hugo, Marseille, France[4]

Received 18 May 2005/Accepted 2 August 2005

Two chimeric enzymes, FLX and FLXLC, were designed and successfully overproduced in *Aspergillus niger*. FLX construct is composed of the sequences encoding the feruloyl esterase A (FAEA) fused to the endoxylanase B (XYNB) of *A. niger*. A C-terminal carbohydrate-binding module (CBM family 1) was grafted to FLX, generating the second hybrid enzyme, FLXLC. Between each partner, a hyperglycosylated linker was included to stabilize the constructs. Hybrid proteins were purified to homogeneity, and molecular masses were estimated to be 72 and 97 kDa for FLX and FLXLC, respectively. Integrity of hybrid enzymes was checked by immunodetection that showed a single form by using antibodies raised against FAEA and polyhistidine tag. Physicochemical properties of each catalytic module of the bifunctional enzymes corresponded to those of the free enzymes. In addition, we verified that FLXLC exhibited an affinity for microcrystalline cellulose (Avicel) with binding parameters corresponding to a K_d of 9.9×10^{-8} M for the dissociation constant and 0.98 μmol/g Avicel for the binding capacity. Both bifunctional enzymes were investigated for their capacity to release ferulic acid from natural substrates: corn and wheat brans. Compared to free enzymes FAEA and XYNB, a higher synergistic effect was obtained by using FLX and FLXLC for both substrates. Moreover, the release of ferulic acid from corn bran was increased by using FLXLC rather than FLX. This result confirms a positive role of the CBM. In conclusion, these results demonstrated that the fusion of naturally free cell wall hydrolases and an *A. niger*-derived CBM onto bifunctional enzymes enables the increase of the synergistic effect on the degradation of complex substrates.

Biopact Towards a green energy pact between Europe and Africa

TUESDAY, JULY 03, 2007

Nanosphere catalyst could improve biodiesel production

Victor Lin, an Iowa State University professor of chemistry and a program director for the U.S. Department of Energy's Ames Laboratory has developed a catalyst based on nanospheres that could revolutionize the way biodiesel is produced. The particles and the precise chemistry filling the channels that run through them could make production cheaper, faster and less toxic.

The new catalyst could also produce a cleaner fuel and a cleaner glycerol co-product. And it could be used in existing biodiesel plants. The technology allows efficient conversion of vegetable oils or animal fats into fuel by loading the nanospheres with acidic catalysts to react with the free fatty acids and basic catalysts to react with the oils. The nanoparticles are recyclable.

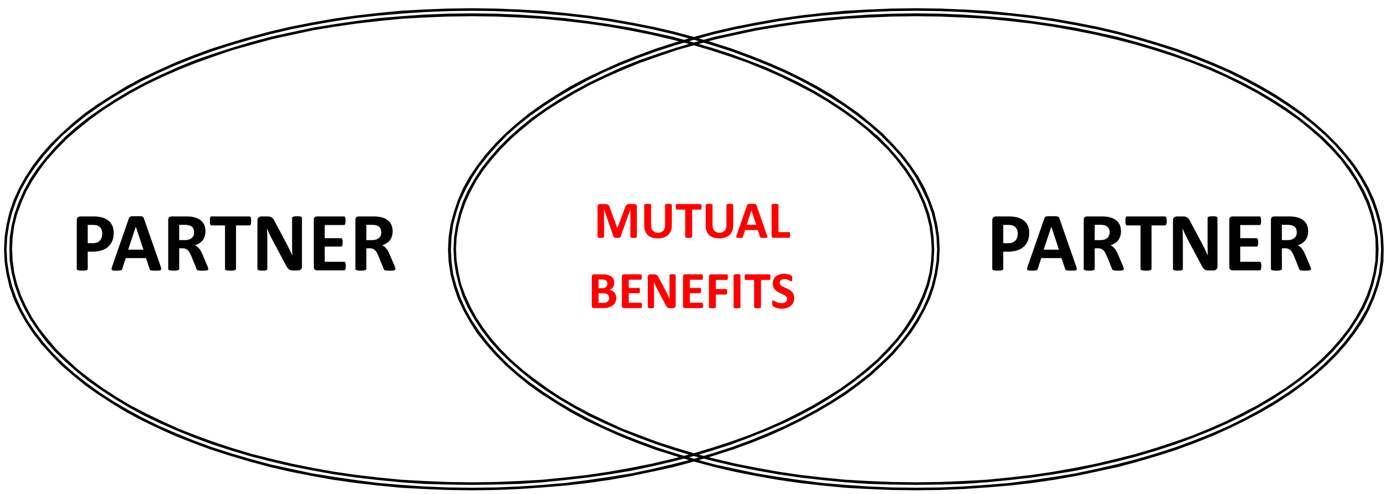
> *This technology could change how biodiesel is produced [...] and could make production more economical and more environmentally friendly.* - Victor Lin, Iowa State University professor of chemistry

http://news.mongabay.com/bioenergy/2007/07/nanosphere-based-catalyst-could.html

Labex Korea

Summary of Challenges and Opportunities

Brazil counts on many other countries producing ethanol and biodiesel from various sources. Great interest in networking and cooperative R&D



Summary of Challenges and Opportunities

Many Institutions Dedicated to Renewable Energy R&D in Brazil

Embrapa Agroenergy: www.cnpae.embrapa.br/

The São Paulo State Research Foundation, FAPESP: www.fapesp.br/english/

FAPESP's Bioenergy Research Program (BIOEN): bioenfapesp.org/

Sugarcane Planters Association, UNICA: www.unica.com.br

Center for Sugarcane Research, CTC: www.ctc.com.br

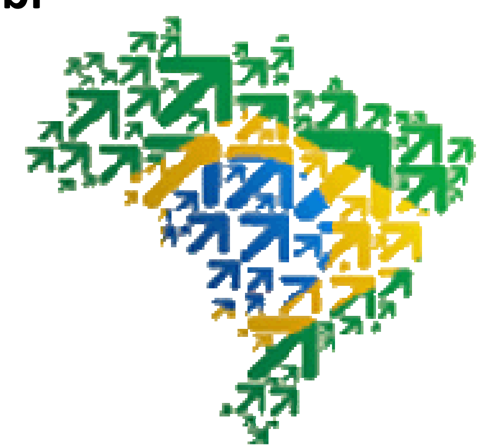
Instituto Agronômico de Campinas – IAC www.iac.sp.gov.br

+ Networks - Ridesa

+ Private companies - Alellyx, Canaviallis (Monsanto)

+ Universities,

Etc…



The Embrapa Labex Program

Embrapa has expanded its cooperation program to Asia
A partnership with the Rural Development Administration - RDA

The Embrapa Labex Program

Inauguration of Embrapa Labex Korea at the Rural Development Administration – RDA, Suwon

The Embrapa Labex Program

Labex Korea Activities and Priorities

Monitoring trends in S&T and opportunities of cooperation

Promoting collaborative projects in strategic areas

Facilitating exchanges of scientists

Identifying training opportunities

Promoting technical meetings and scientific exchange

Follow-up on joint research projects

The Embrapa Labex Program

"Our vision of future impact of Labex "

International networking - cutting-edge research - capacity building - access knowledge increased funding - increased visibility - dialogue in international fora, etc,etc...

"Agroecology"

"Animal Science"

"Genetic Resources"

"Advanced Biology"

"Engineering / automation"

"Agroenergy"

"Botany"

Thank You - 감사합니다

labex.korea@ymail.com

Embrapa

RDA

Embrapa Labex Korea
Brazilian Agricultural Research Corporation – Embrapa
Rural Development Administration – RDA

Mauricio Antonio Lopes, Ph.D.
Scientist – Coordinator

International Technology Cooperation Center - ITCC
Rural Development Administration - RDA
250 Seodun-dong, Gwonseon-gu, Suwon 441-707, Republic of Korea
Office: 82-(0)31-299-1099 / Fax: 82-(0)31-293-9359
labex.korea@ymail.com http://labexkorea.wordpress.com

Embrapa

RDA

브라질 농업연구청 아시아협력연구센터
Embrapa Labex Korea
Brazilian Agricultural Research Corporation – Embrapa

마우리시오 안토니오 로페스
농학박사, Labex 상주조정관

농촌진흥청 국제농업기술협력센터
(441-707) 경기도 수원시 권선구 서둔동 250
사무실: 82-(0)31-299-1099 / 팩스: 82-(0)31-293-9359
labex.korea@ymail.com http://labexkorea.wordpress.com