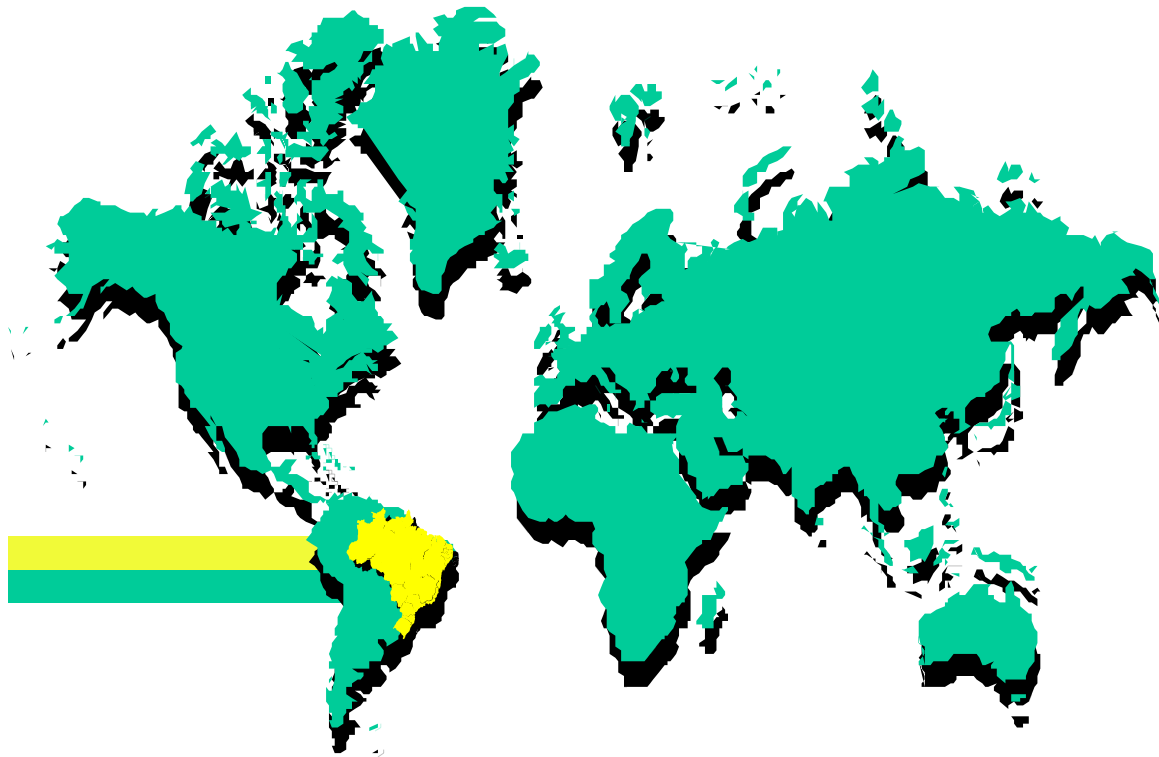




# - BRAZILIAN BIOENERGY - A SUCCESSFUL CASE OF INNOVATION



**The 1st FEALAC Expert Meeting  
on Current Issues**

**“Renewable Energy R&D”**

Seoul, Republic of Korea

October 8th, 2009

**Maurício Antônio Lopes  
Brazilian Agricultural Research Corporation  
Embrapa Labex Korea**



# Summary

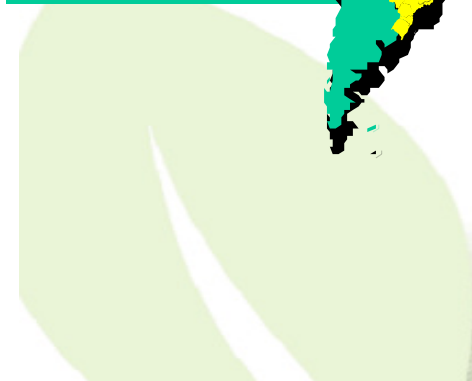
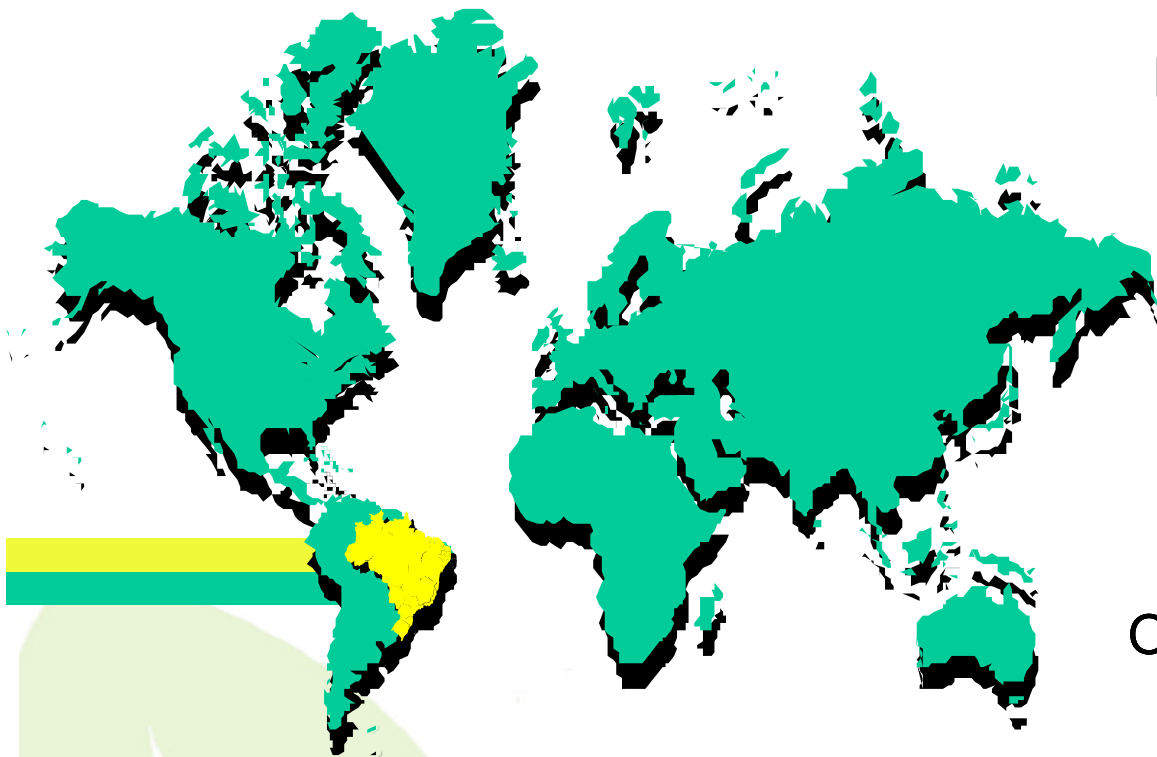
Introduction

Renewable Energy in Brazil

Sugarcane and Ethanol

Biodiesel

Opportunities and Challenges  
for the Future

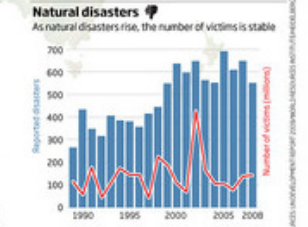
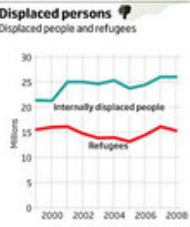
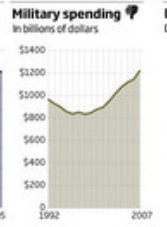
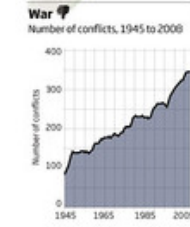
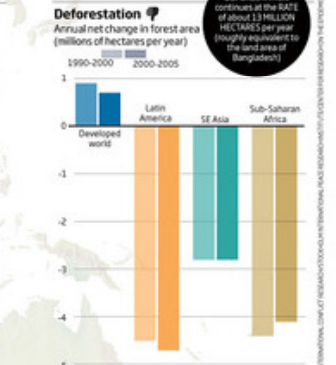
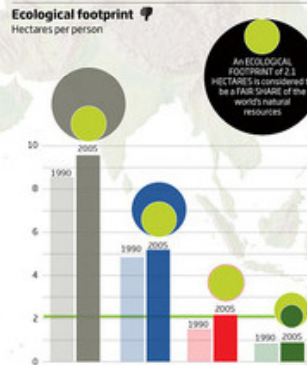
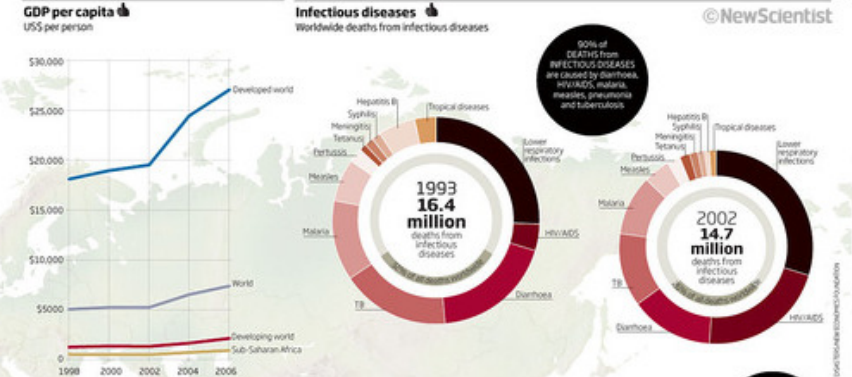
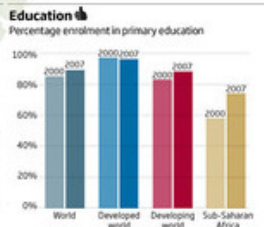
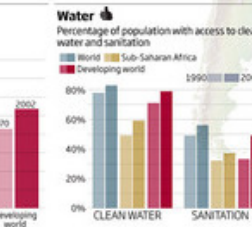
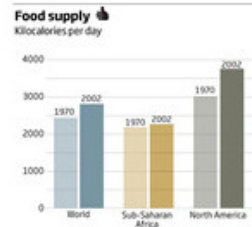
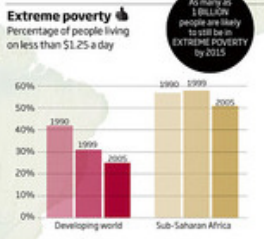
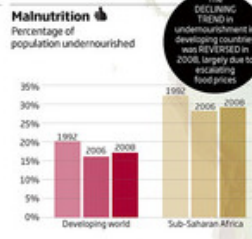
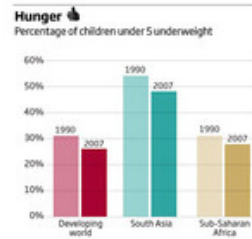
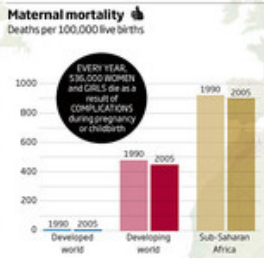
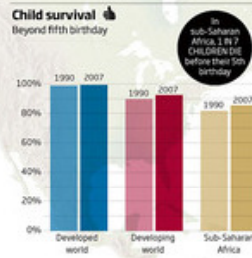
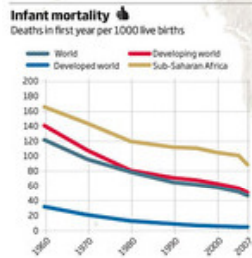


# Is the World Getting Better or Worse?



Is the world getting better or worse?

By most measures, living standards are improving across the world...  
Less encouragingly, the environment is clearly in trouble...



Human quality of life is improving at the expense of the environment...



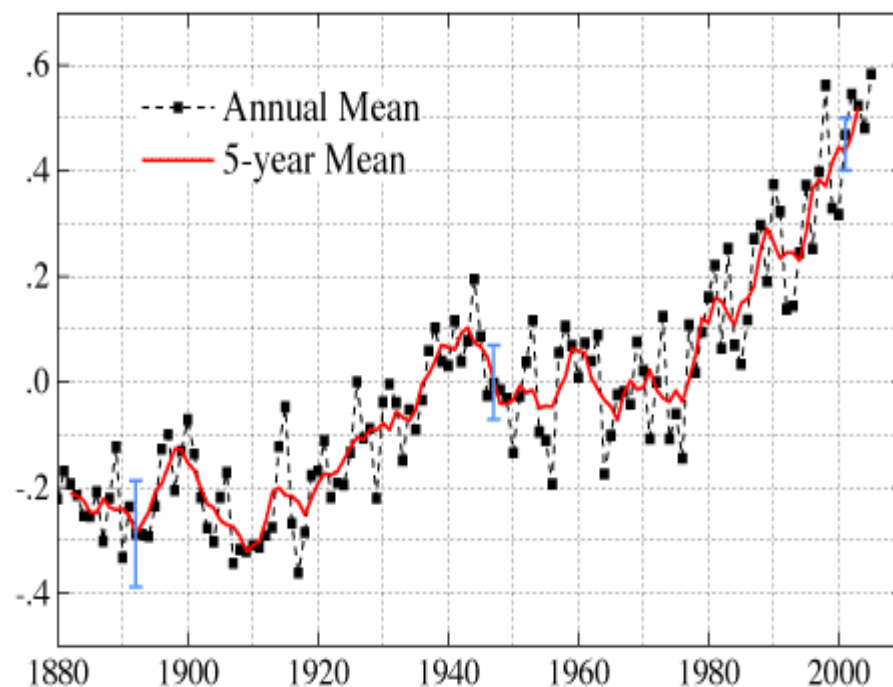
## Pressure for Changes...

### Global Climate Change & Sustainability:

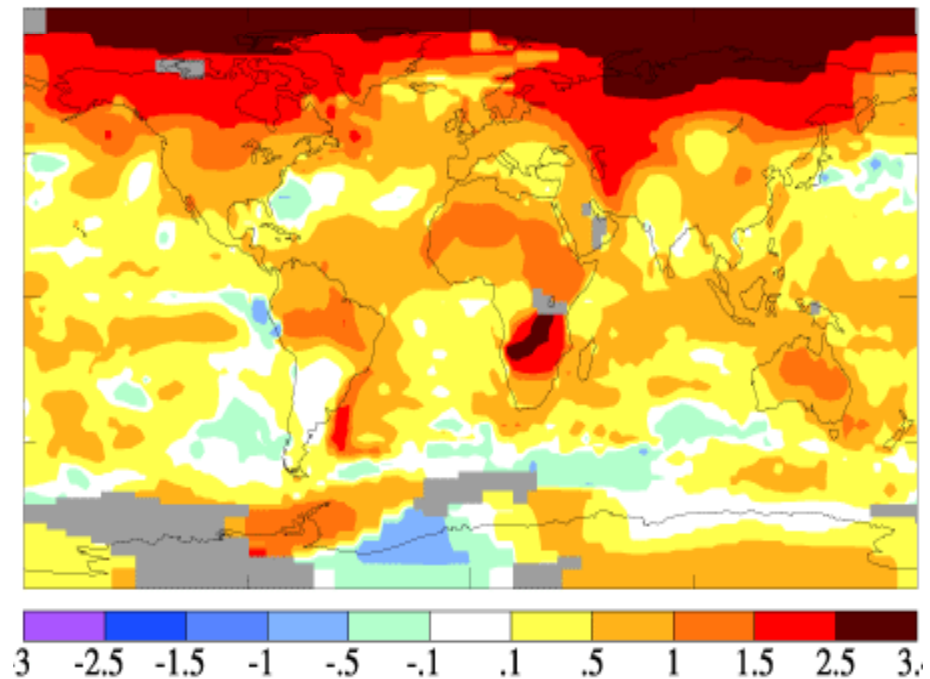
Pressures for reduction of greenhouse gas emissions

More sustainable use of the natural resource base

(a) Global-Mean Surface Temperature Anomaly (°C)



(b) 2005 Surface Temperature Anomaly (°C)





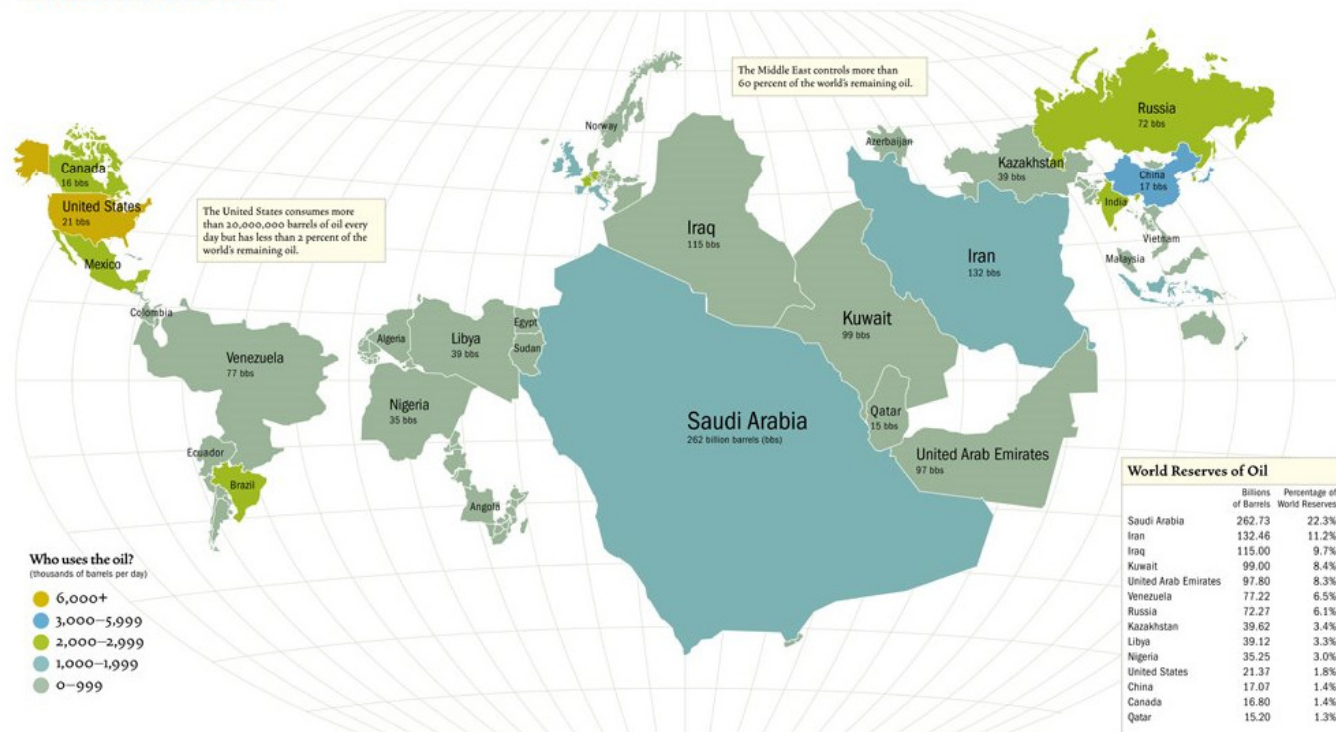


# Pressure for Changes...

## Limitations of conventional energy resources:

Pollution - Finite resources - Uneven distribution of reserves

### Who has the oil?





## Pressure for Changes...

### Energy security (as food security):

Nations want to produce their own energy

Nations want access to secure sources of energy



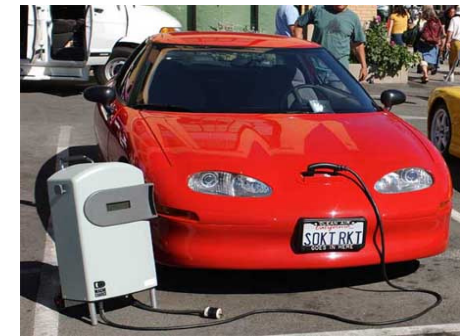
<http://lanxess.com/ecology/climate-protection/renewable-resources/biomass/>







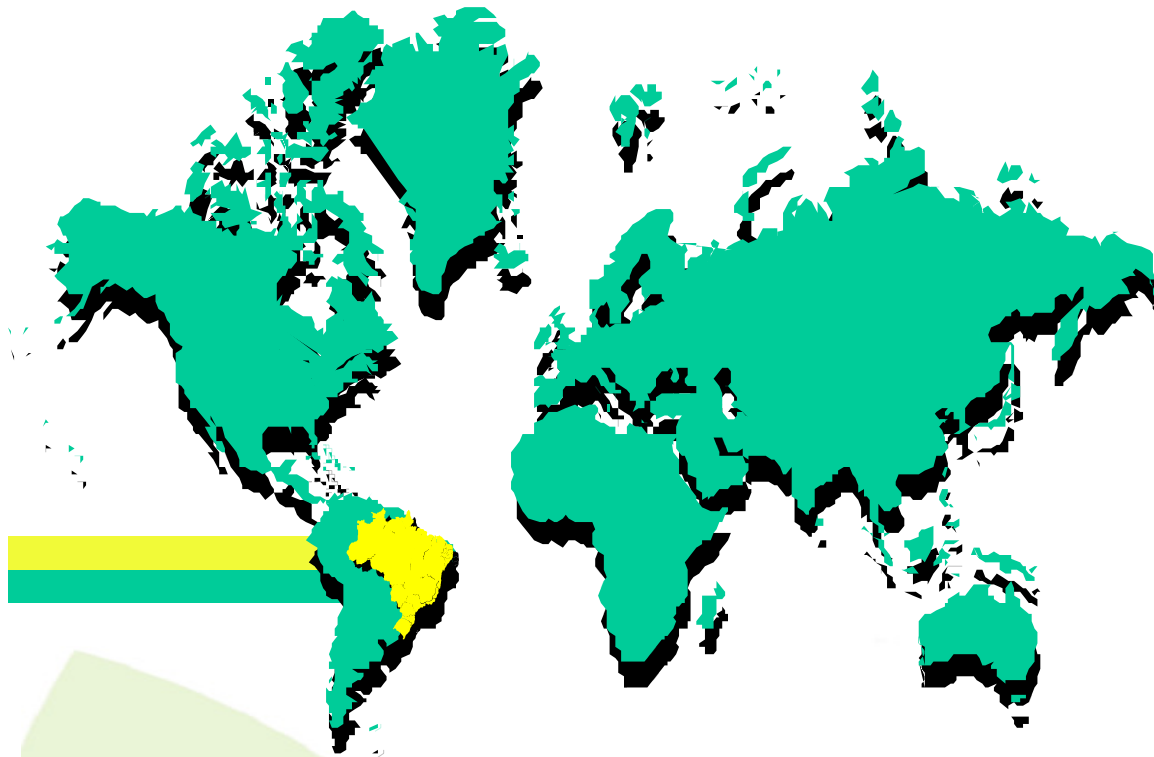
# Renewable Energy Gains Global Momentum





# The Brazilian Experience

## Development and Use of Renewable Energy Sources



The largest economy in South America

Fifth largest and fifth most populated country in the world

190 million people, 9th GDP

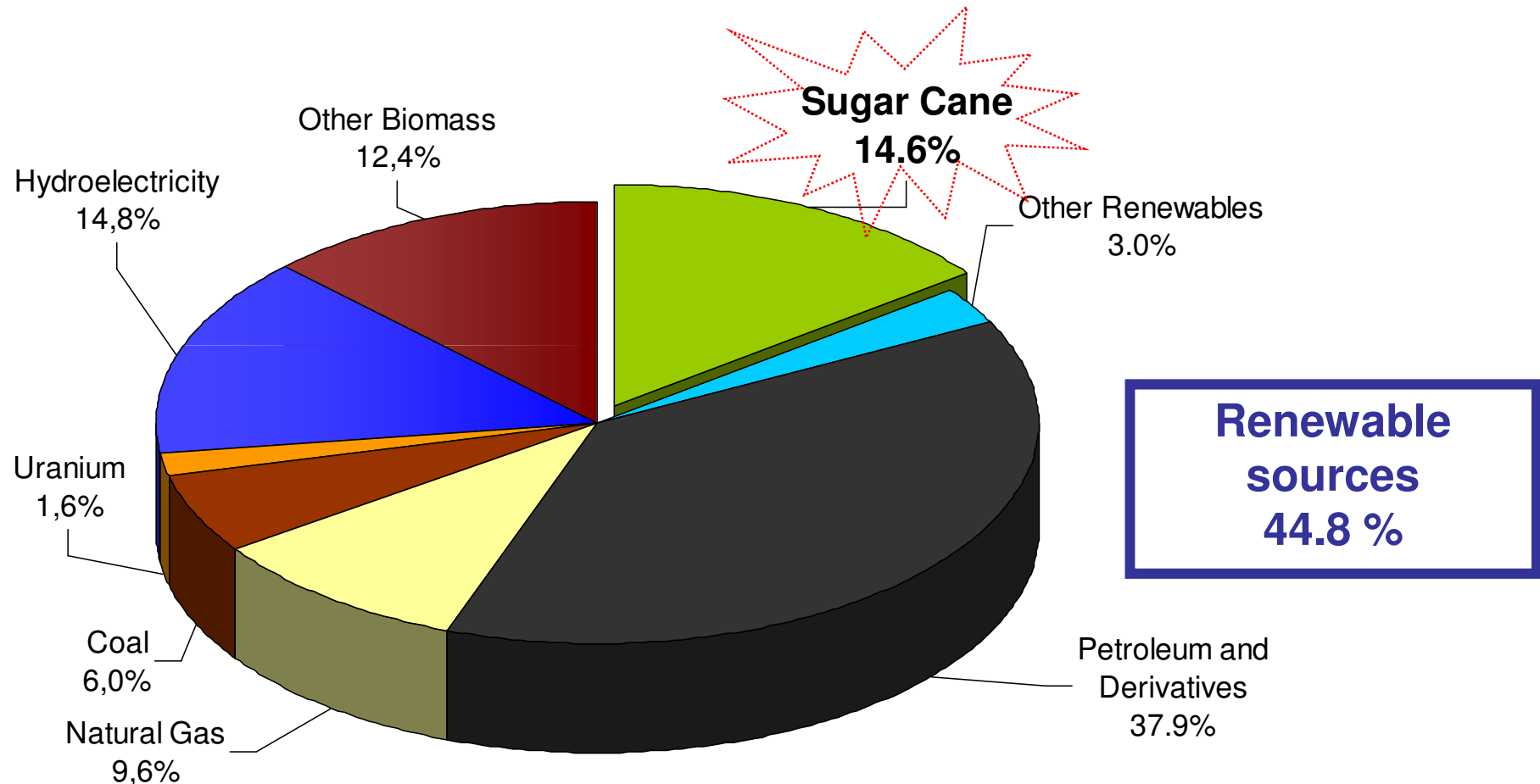
Brazil has been developing renewable sources of energy for more than 75 yr.





# Renewable Energy in Brazil

Close to 45% of Brazil's energy comes from renewable sources



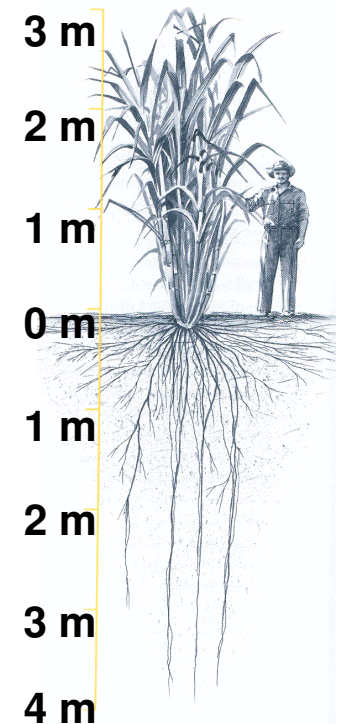
Renewables in Brazil: 44.8%; World: 14%; OECD: 6%





# Renewable Energy 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



## 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

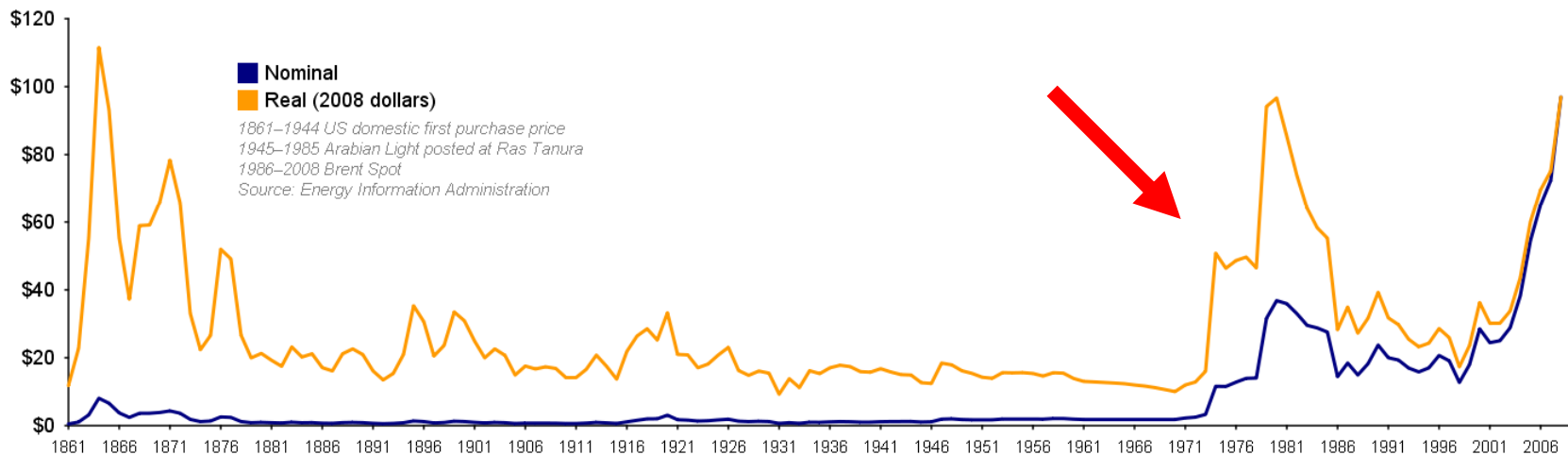


**First Brazilian car fuelled by a blend of ethanol and gasoline - 1925**



# 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

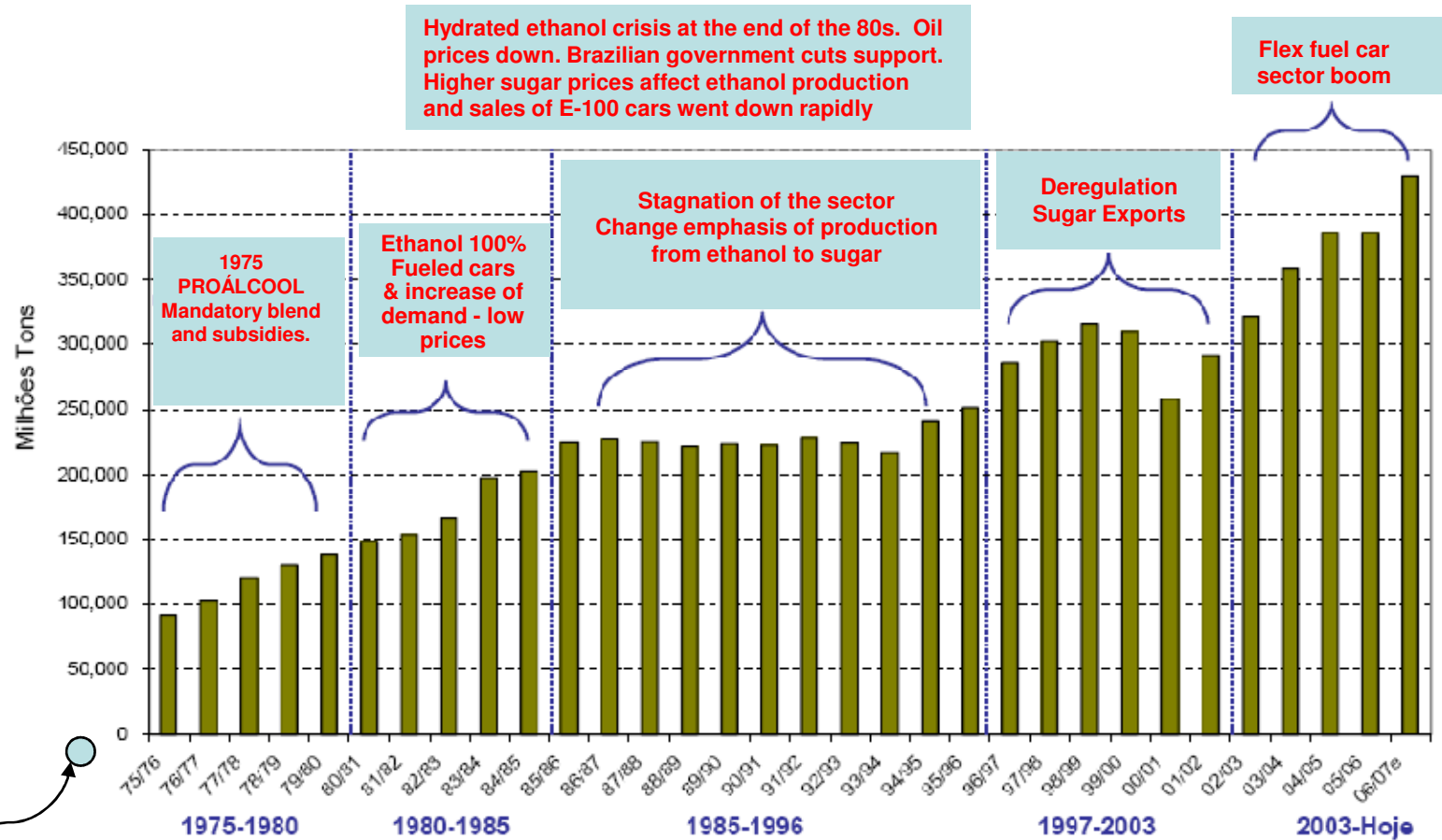


Graph of oil prices from 1861–2007, showing a sharp increase in 1973/1974, and again during the 1979 energy crisis. The orange line is adjusted for inflation.



# The Evolution of the Brazilian Ethanol Industry

Processed sugarcane since the 1970's - M tons



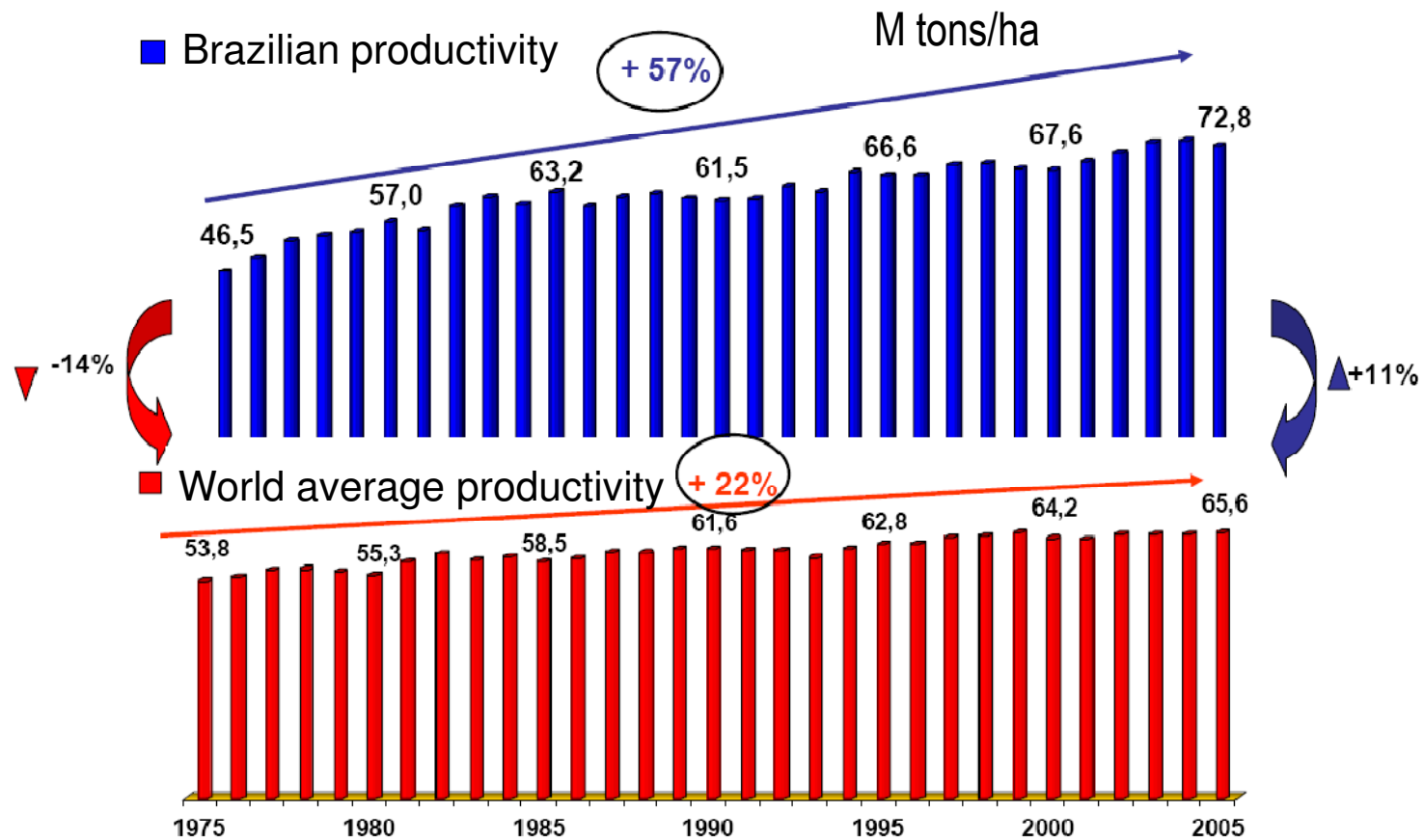
1973 Oil crisis & low sugar prices.





# The Evolution of the Brazilian Ethanol Industry

R&D - Evolution of the sugarcane production systems



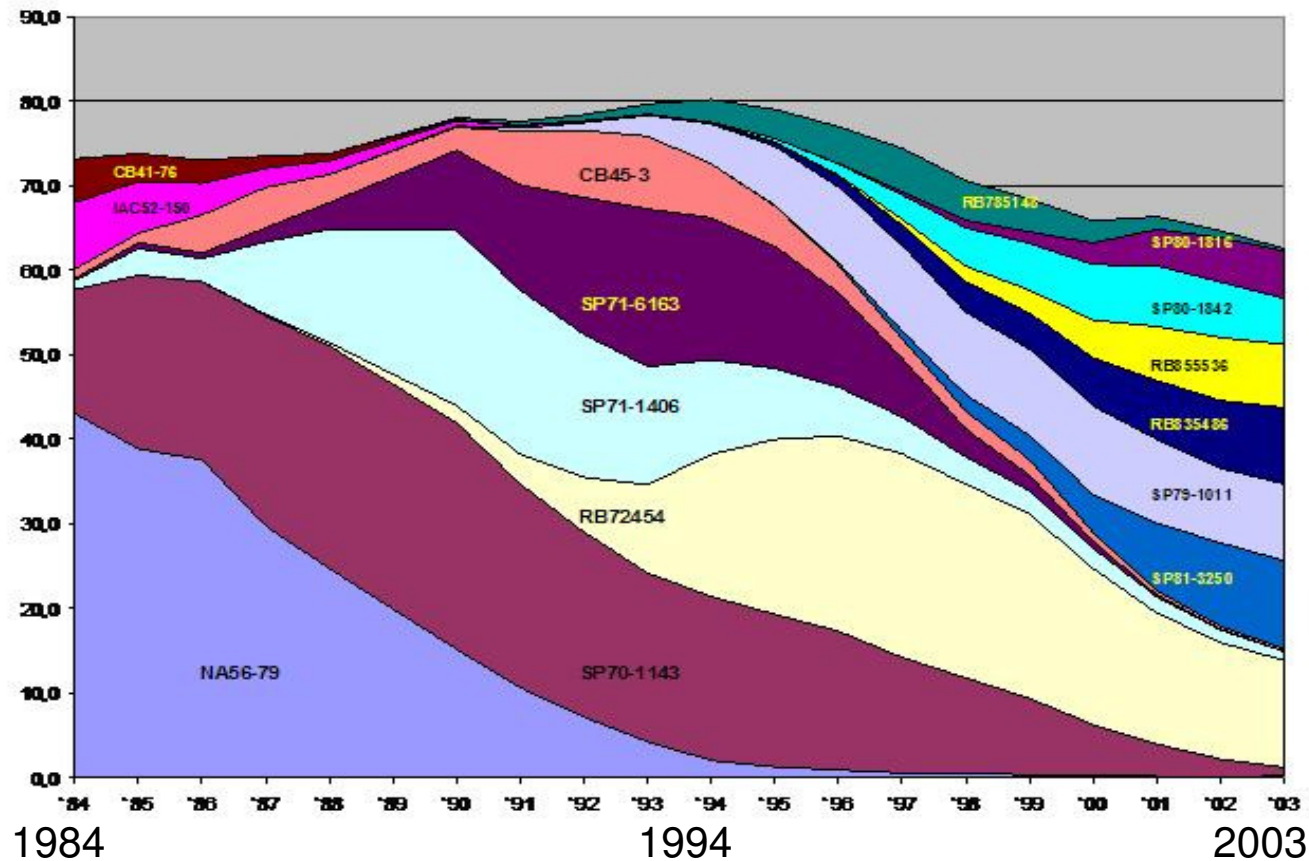
Brazilian sugarcane productivity is 11% higher than the world average productivity





# The Evolution of the Brazilian Ethanol Industry

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



Developed by 3 research organizations

- CTC
- Ridesa
- IAC

Plus private companies

- Alellyx
- Canaviallis

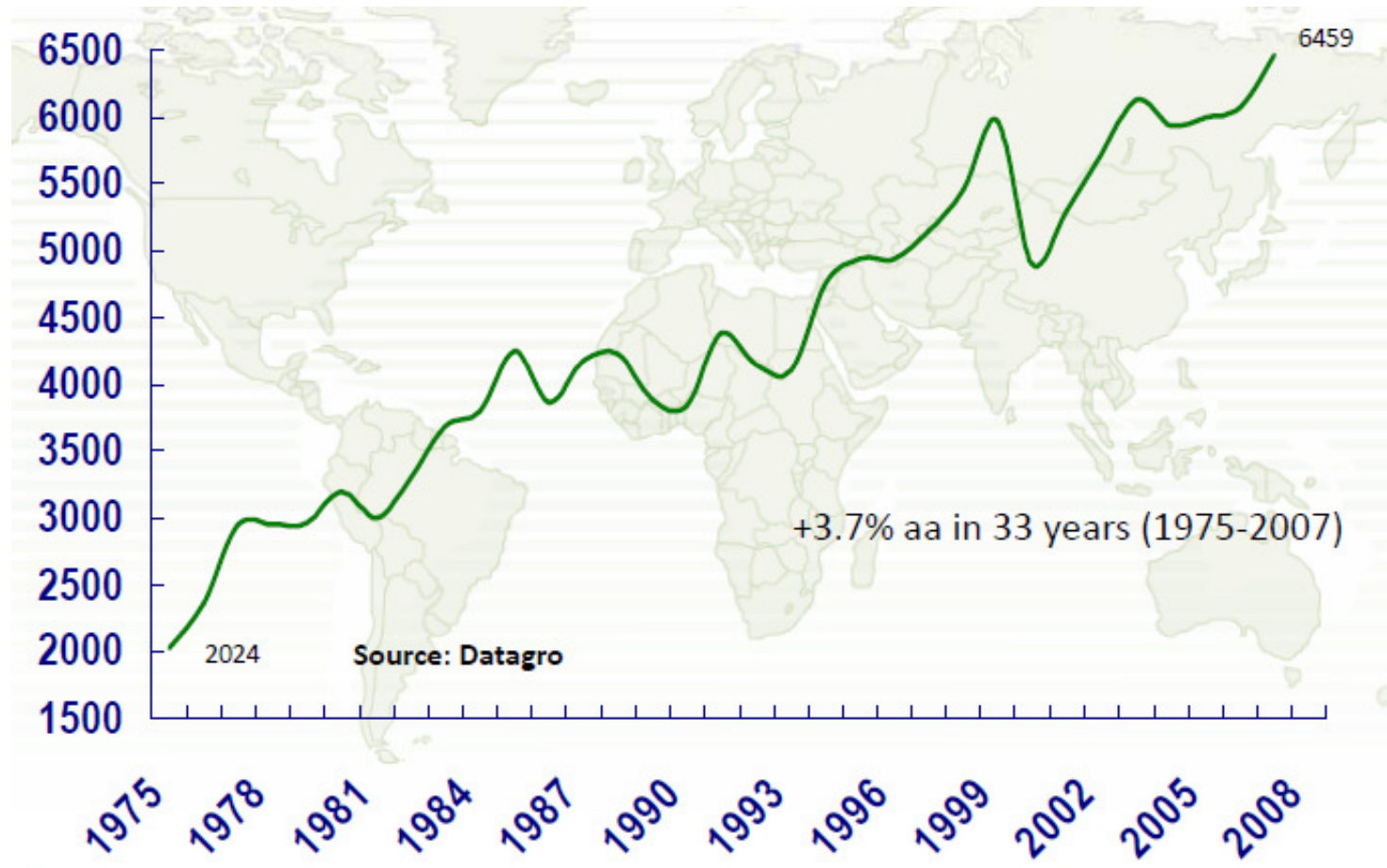
# of Varieties Developed = 550

# of Varieties Released since 1995 = 51



# The Evolution of the Brazilian Ethanol Industry

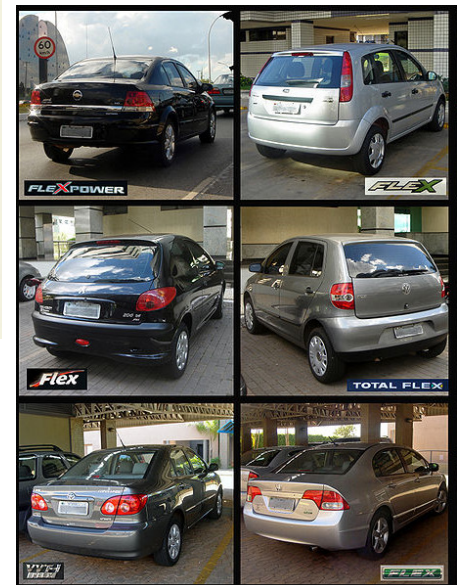
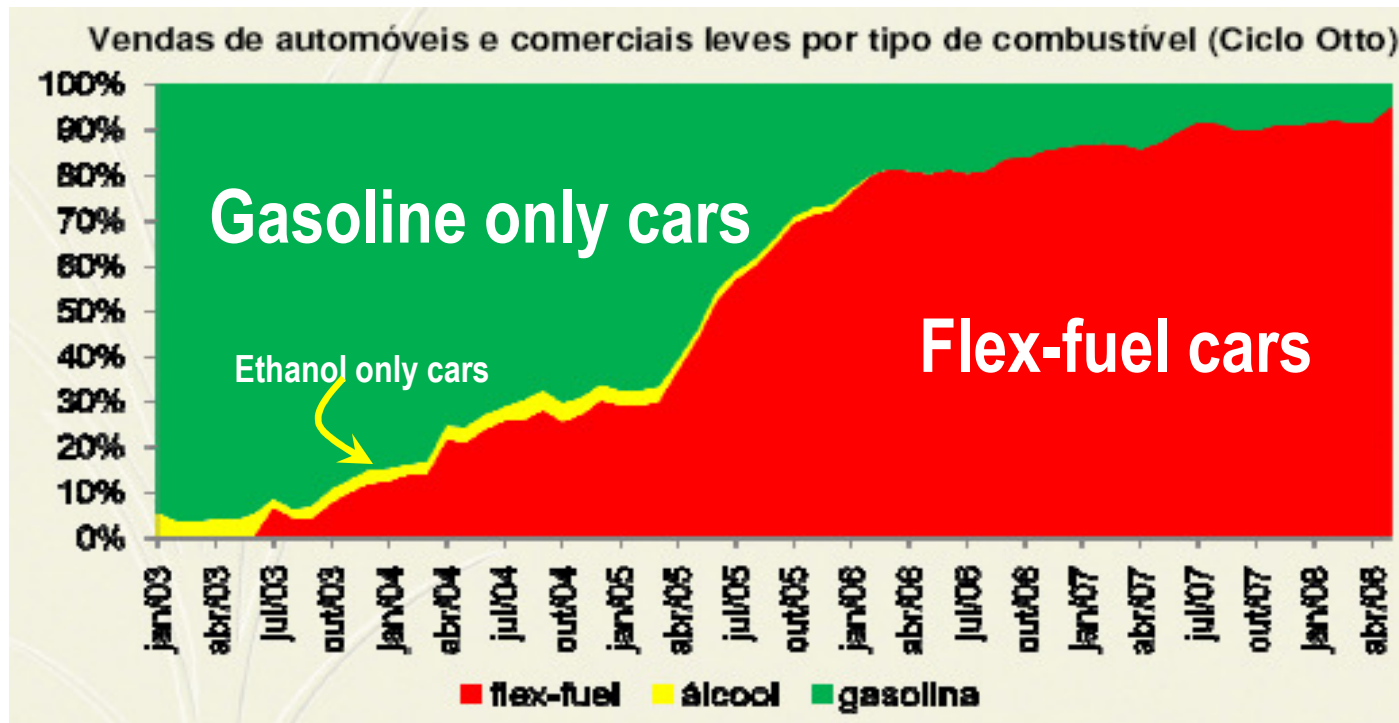
R&D - Evolution of agro industrial yield – liters of hydrous ethanol equivalent per ha





# The Evolution of Auto Industry in Brazil

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

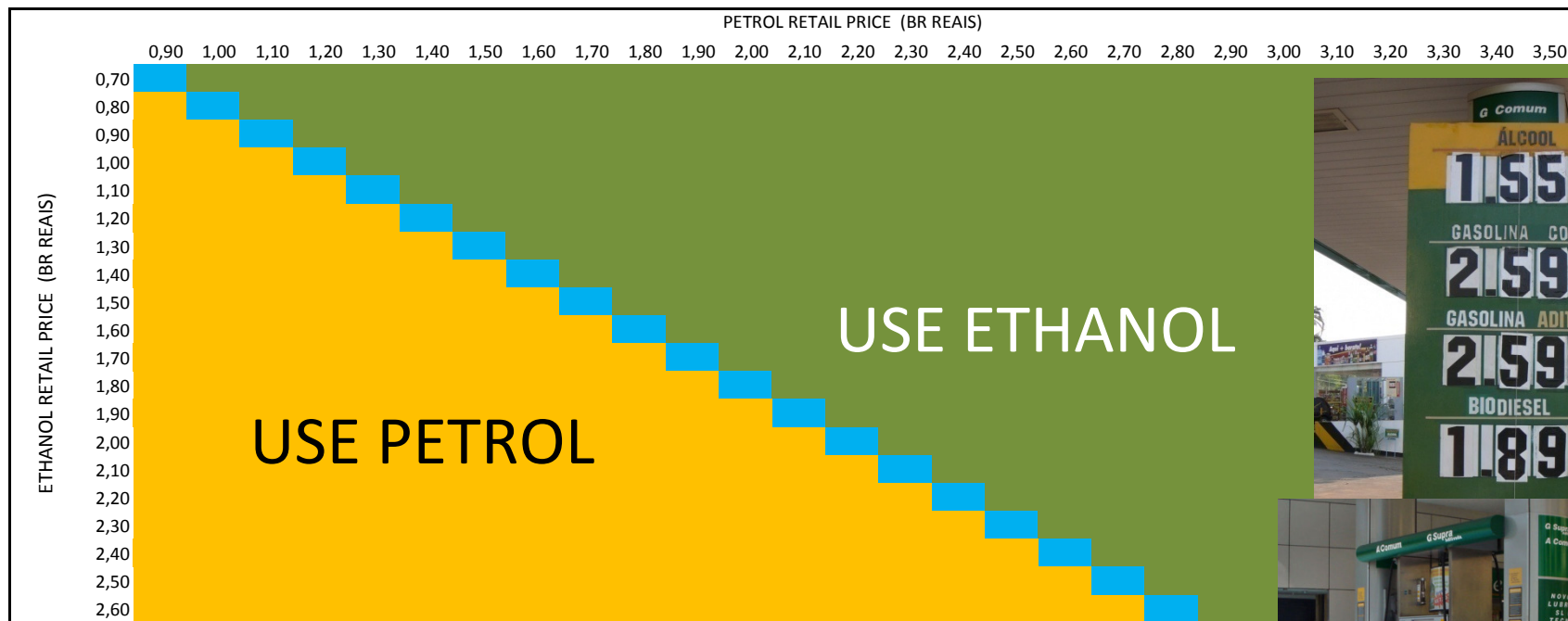




# The Evolution of Logistics and Distribution

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

**Consumer choice:** The flex fuel technology allows consumers to choose any mixture of ethanol and gas each time the car must be refueled.



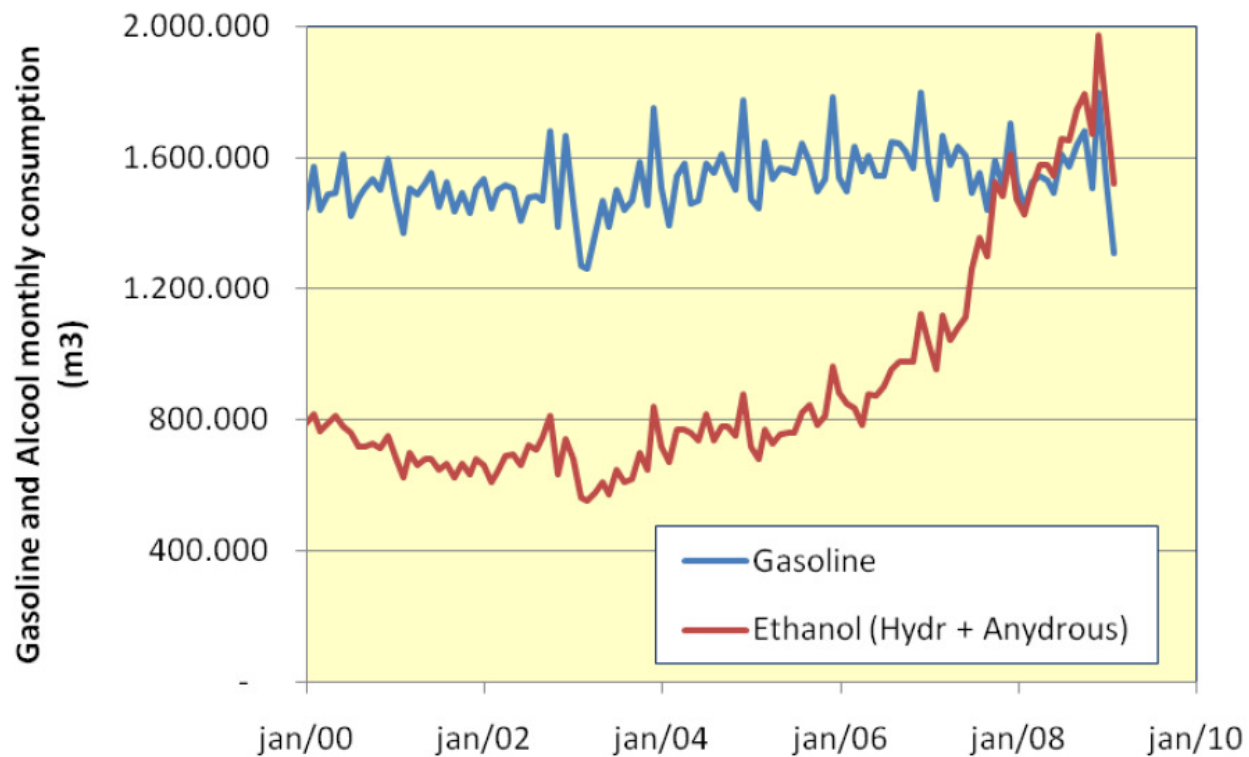
Consumer decision table to be used in the petrol station.  
Source: based in a GM table distributed to flex car owners.





# ` Gasoline is Becoming the Alternative Fuel in Brazil `

Changes in Ethanol and Gasoline use in Brazil

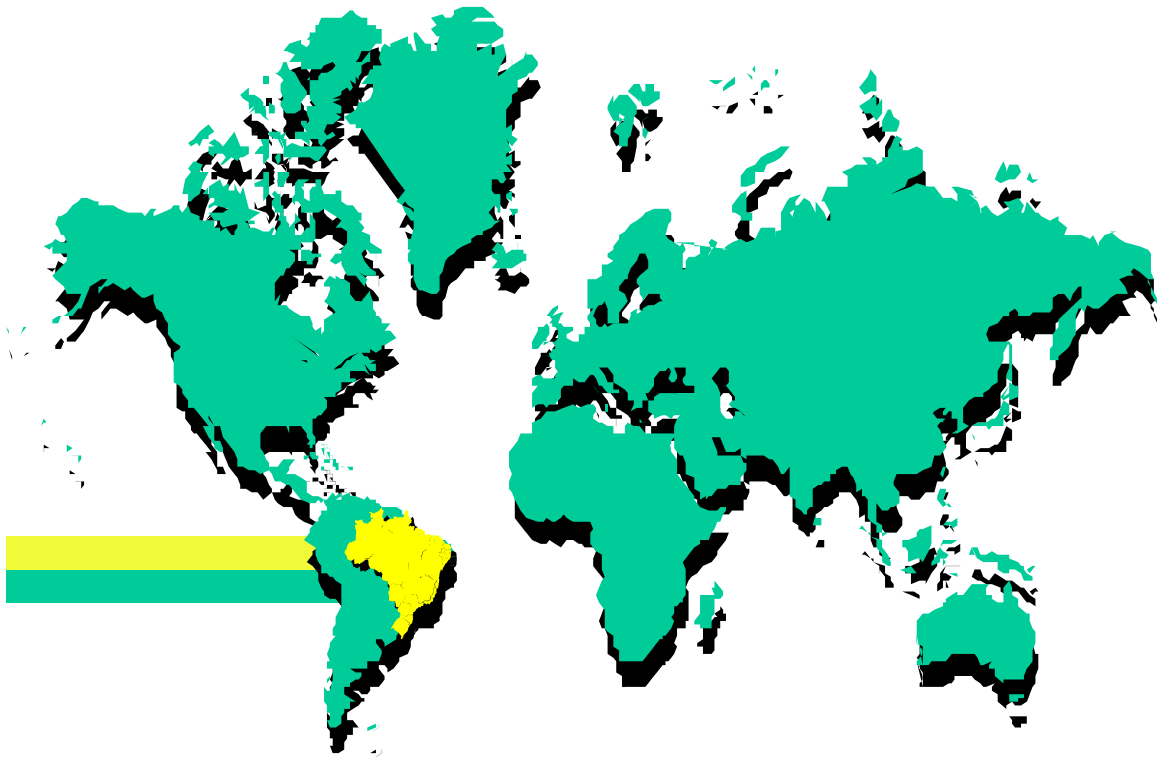






# Renewable Energy in Brazil

A few recurrent questions...



Is ethanol production from sugarcane sustainable?

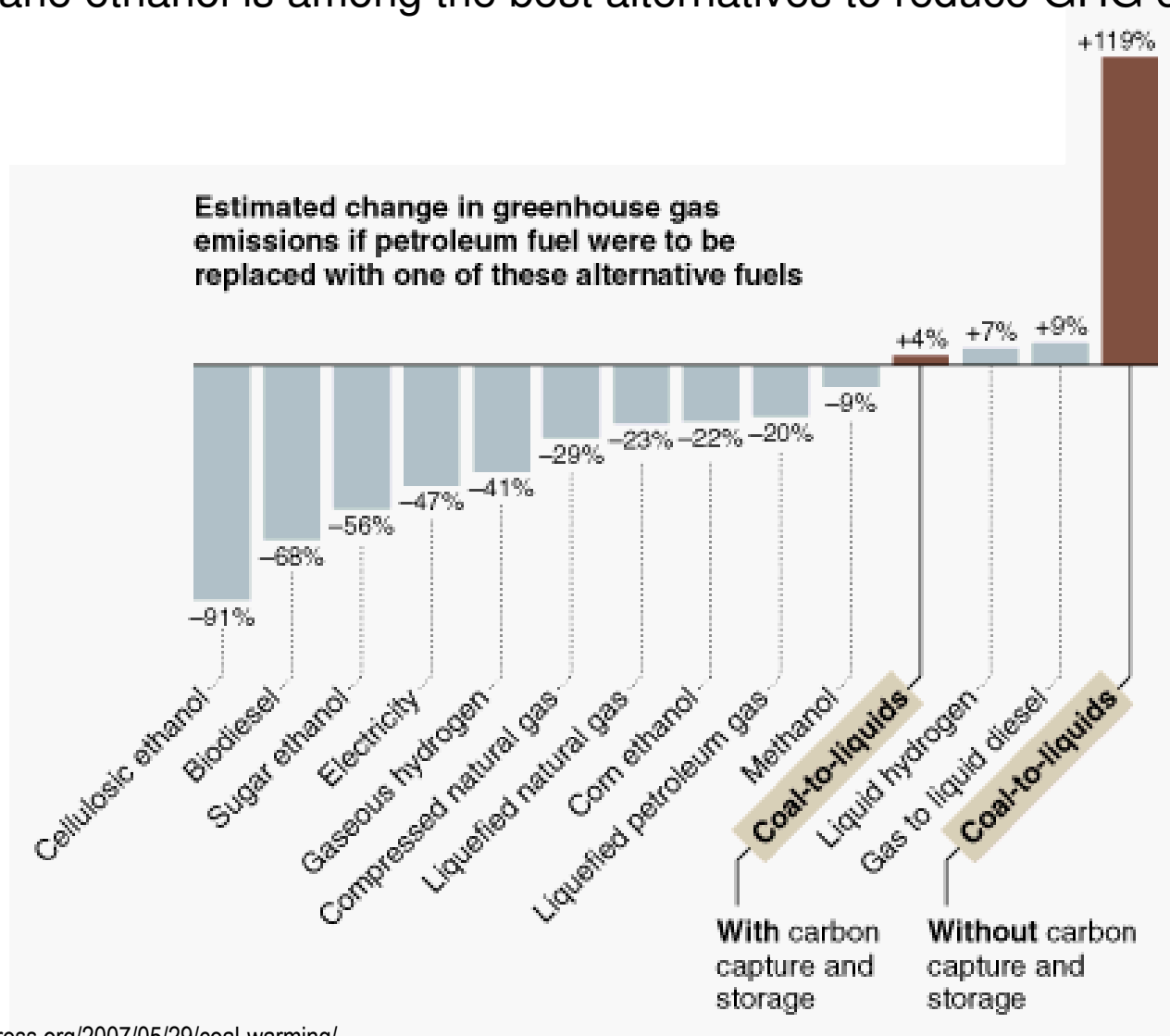
Which other sources can complement ethanol?

What are the challenges and opportunities for the future?



# Sustainability of Sugarcane Etanol

Sugarcane ethanol is among the best alternatives to reduce GHG emissions



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



# Sustainability of Sugarcane Etanol

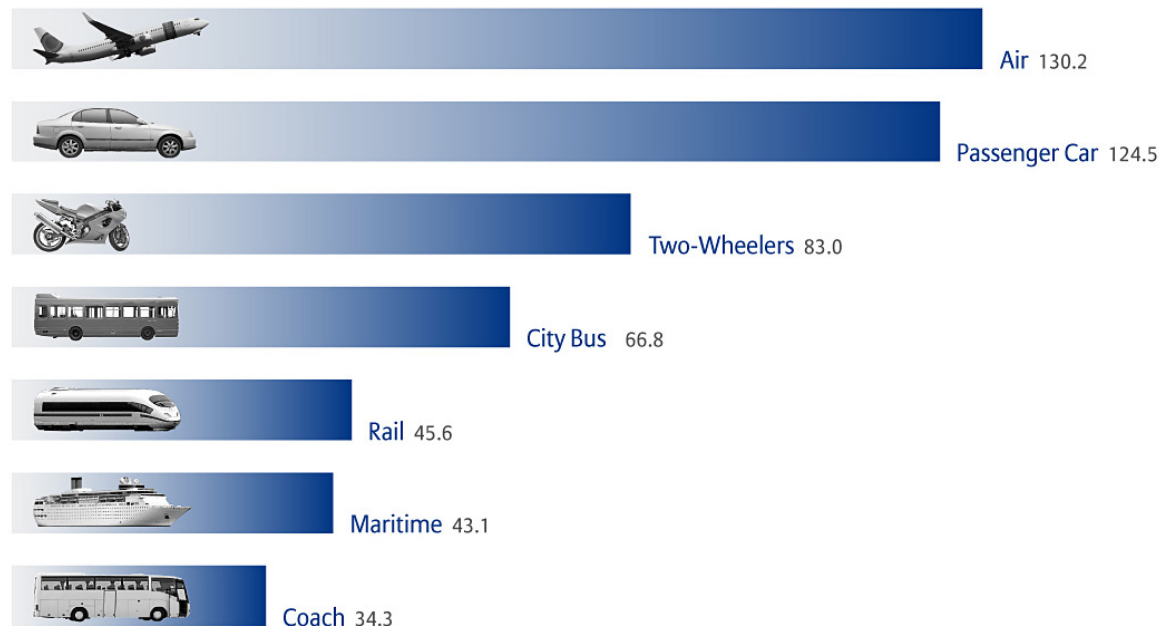
Ethanol as a fuel is targeting a segment of highest impact in GHG emission

## The Climate Impacts of How We Get Around



Transportation accounts for over 23 percent of all global carbon dioxide emissions. See what modes of human transport produce the most emissions per kilometer.

### CO<sub>2</sub> Emissions Per Passenger (grams per kilometer)

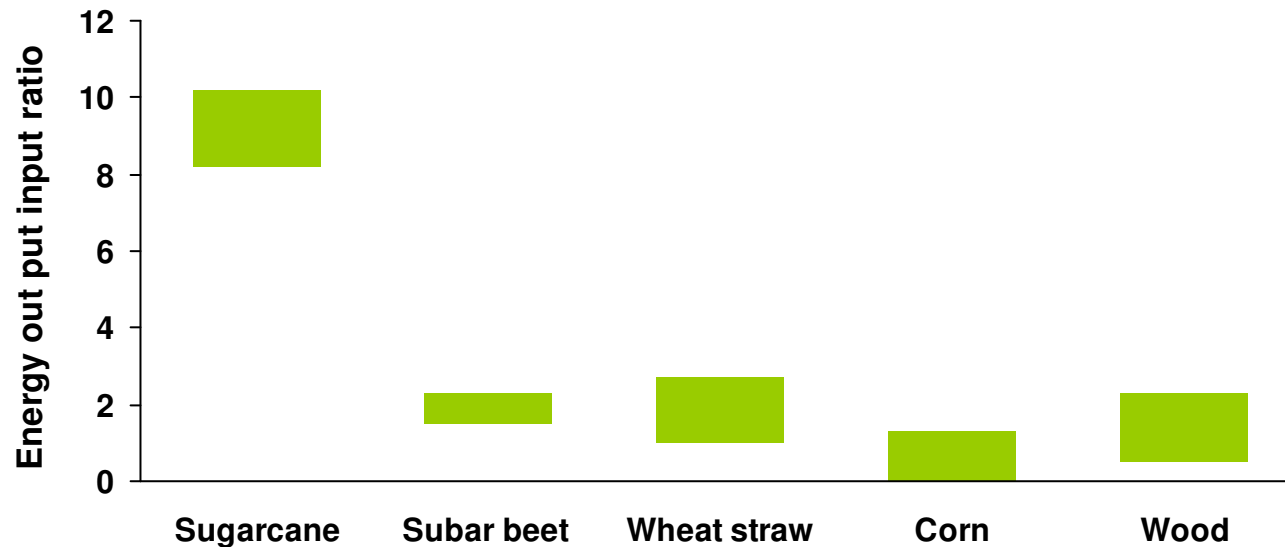


Source: European Environment Agency  
The publication of this graphic is free of charge provided that users credit Allianz SE.  
Graphics are available in the media section of the Allianz Knowledge Partnersite: [www.knowledge.allianz.com/en/media/graphics](http://www.knowledge.allianz.com/en/media/graphics)



# Energy efficiency of Sugarcane

Sugarcane is the most energy efficient raw material to produce ethanol



Raw material	Production /ha (kg)	Quantity of Ethanol /ha	Energy Output/ Energy Input
sugarcane	85.000	7.080 liter	8.3
Corn	10.000	4.000 liter	1.3 - 1.8

Energy balance of ethanol production from different feedstocks



# Energy efficiency of Sugarcane

Innovative cogeneration plants generate energy from sugar cane waste - completely carbon-neutral.







## Energy efficiency of Sugarcane

Innovative cogeneration plants generate energy from sugar cane waste - completely carbon-neutral.



**Mills and distilleries also generate electric and mechanical power, most of it for self consumption. That is 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<sub>2</sub> equivalent worth of emissions could be avoided using ethanol, the bagasse and the additional electric power surplus.**



# Energy efficiency of Sugarcane

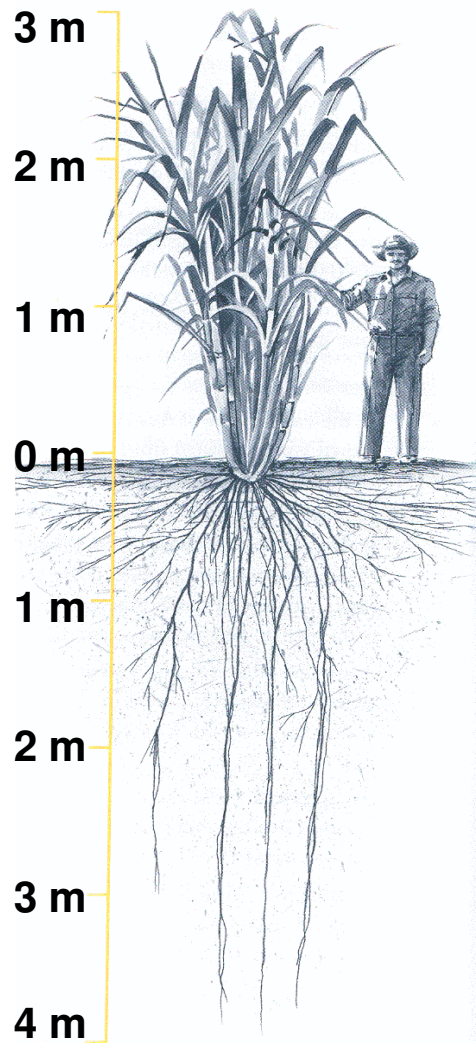
## Cellulosic Ethanol from Sugarcane

- 
- A faint, light-colored world map is visible in the background of the text area, showing the outlines of continents and countries.
- 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.



# Sustainability of Sugarcane Etanol

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



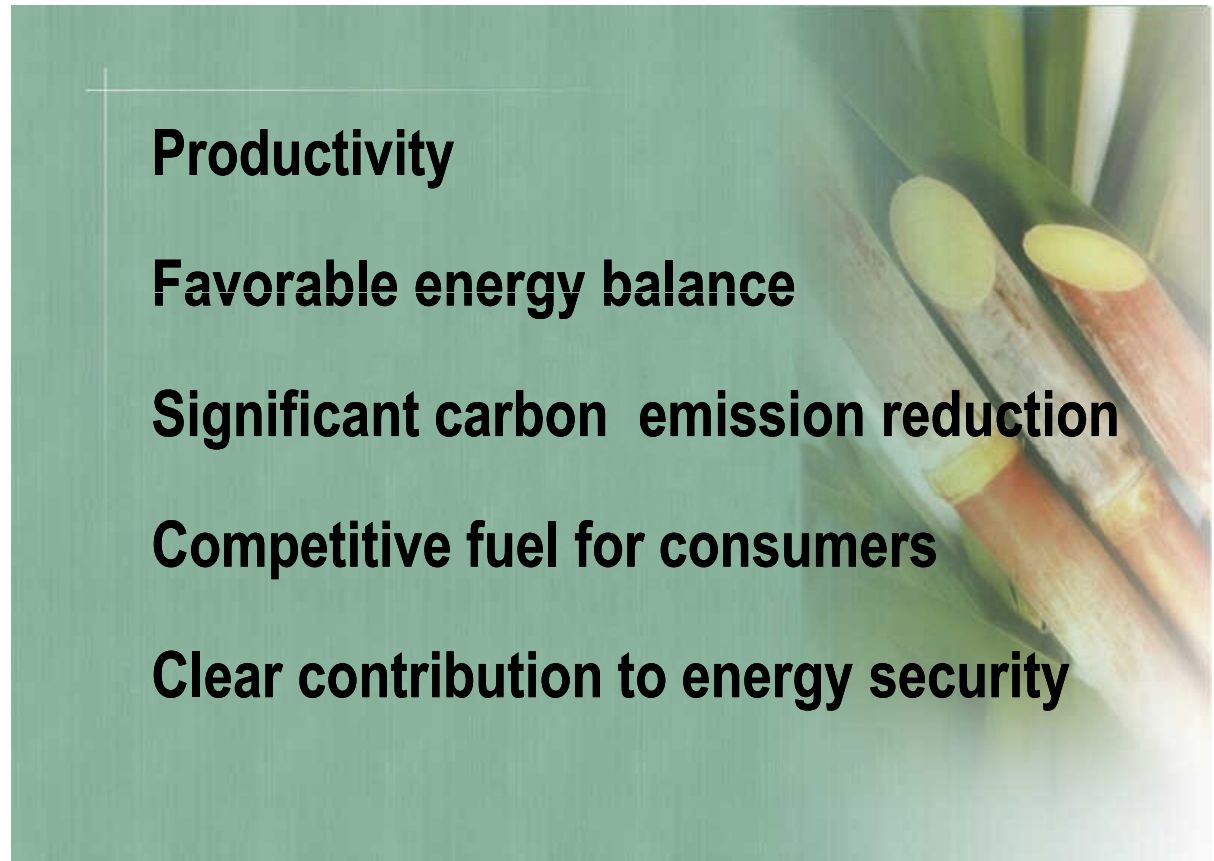
**Productivity**

**Favorable energy balance**

**Significant carbon emission reduction**

**Competitive fuel for consumers**

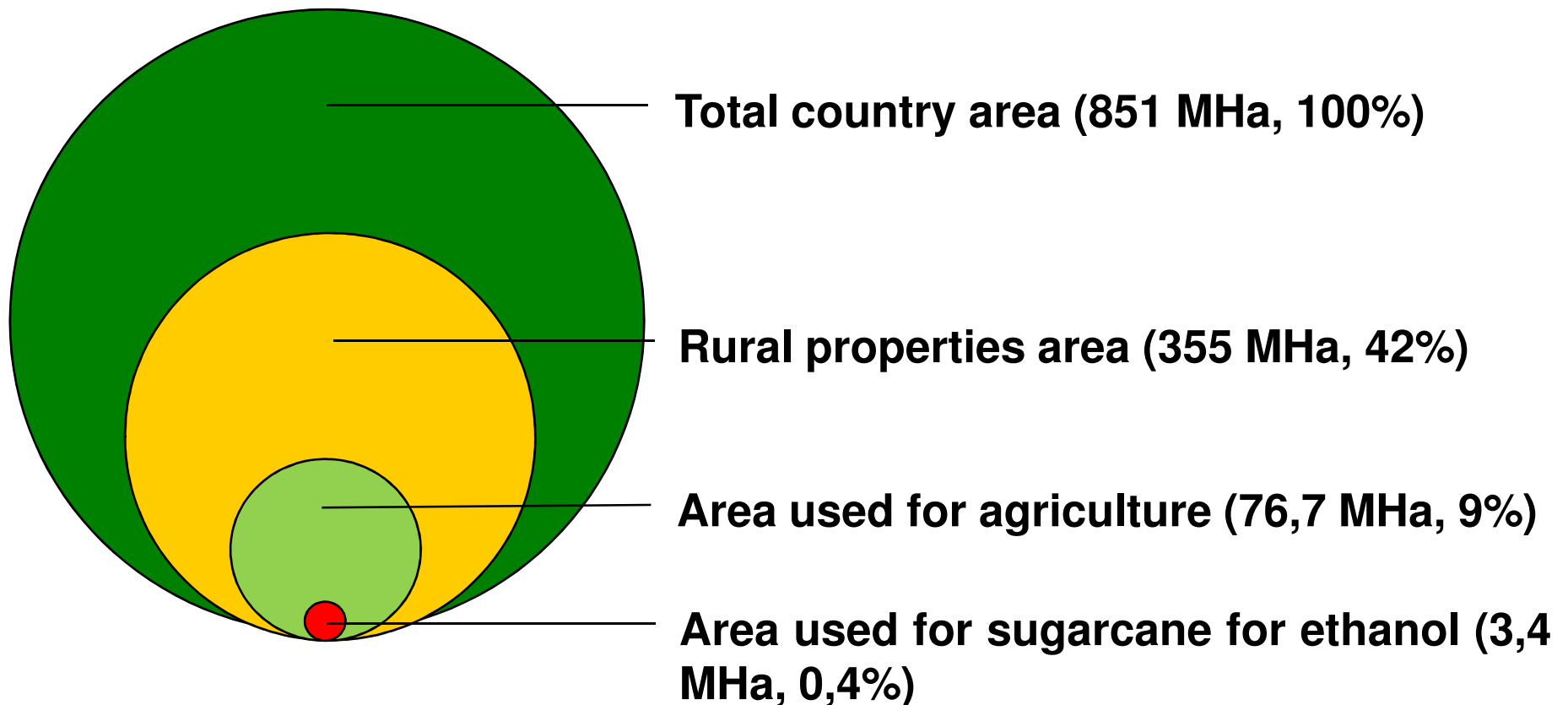
**Clear contribution to energy security**





# Sustainability of Sugarcane Production in Brazil

Sugarcane for ethanol uses less than 1,0% of the total area in Brazil







# Brazil is Managing Sugarcane Expansion

Brazil increases environmental preservation measures with sugarcane zoning proposal



New bill based on a zoning plan developed by Embrapa establishes that areas for cultivation of sugarcane may reach a maximum of 64 million hectares.





# Brazil is Managing Sugarcane Expansion

Brazil increases environmental preservation measures with sugarcane zoning proposal

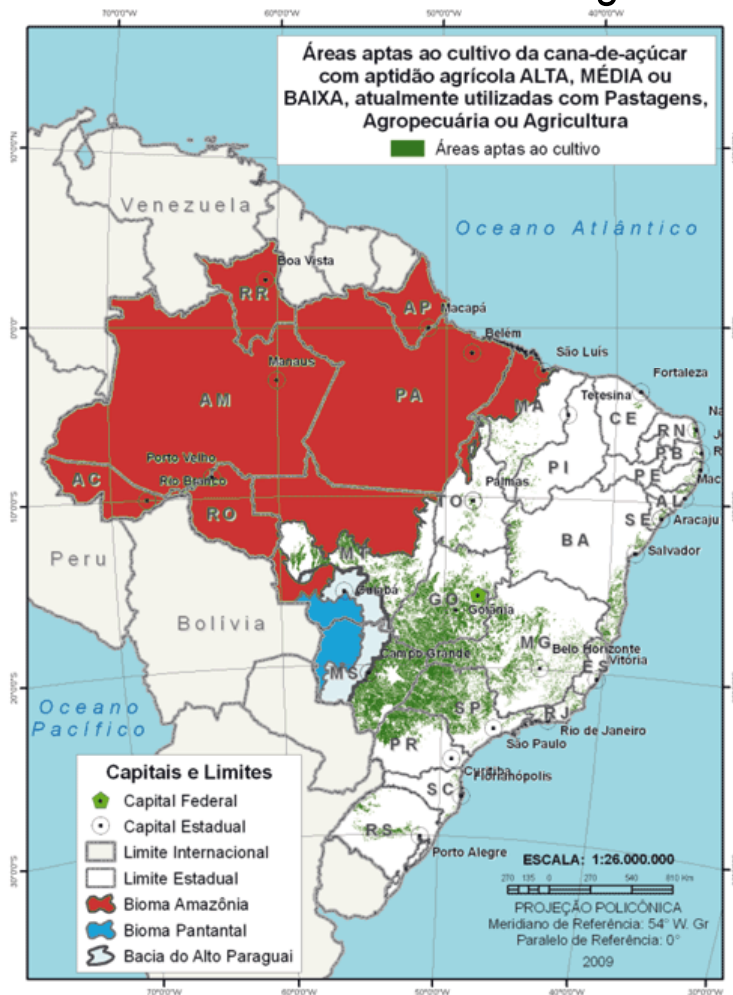


Coupled with the areas not suitable for sugarcane farming, the Bill will effectively make 92.5% of Brazil's national territory off-limits for sugarcane farming and processing.



# Brazil is Managing Sugarcane Expansion

Brazil increases environmental preservation measures with sugarcane zoning proposal

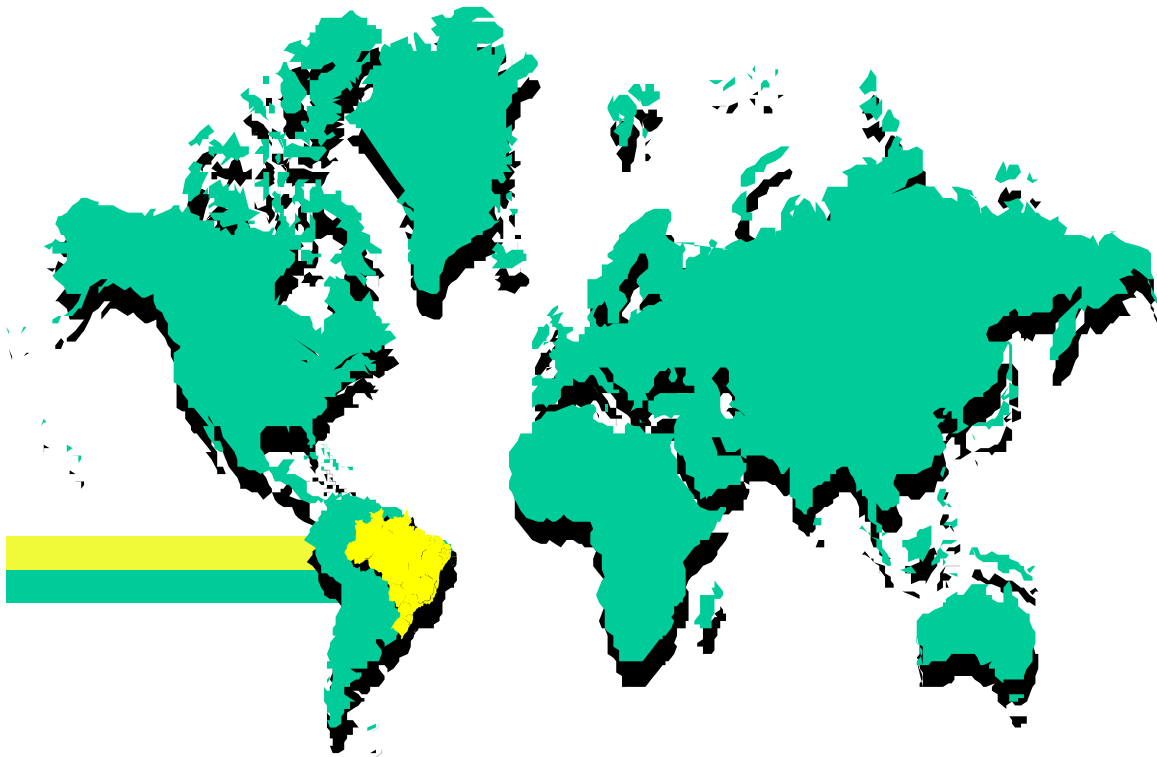


The Bill makes indigenous lands – including the Amazon, Pantanal, and Upper Paraguay River Basin regions – off-limits for the sugarcane industry expansion



# Renewable Energy in Brazil

A few recurrent questions...



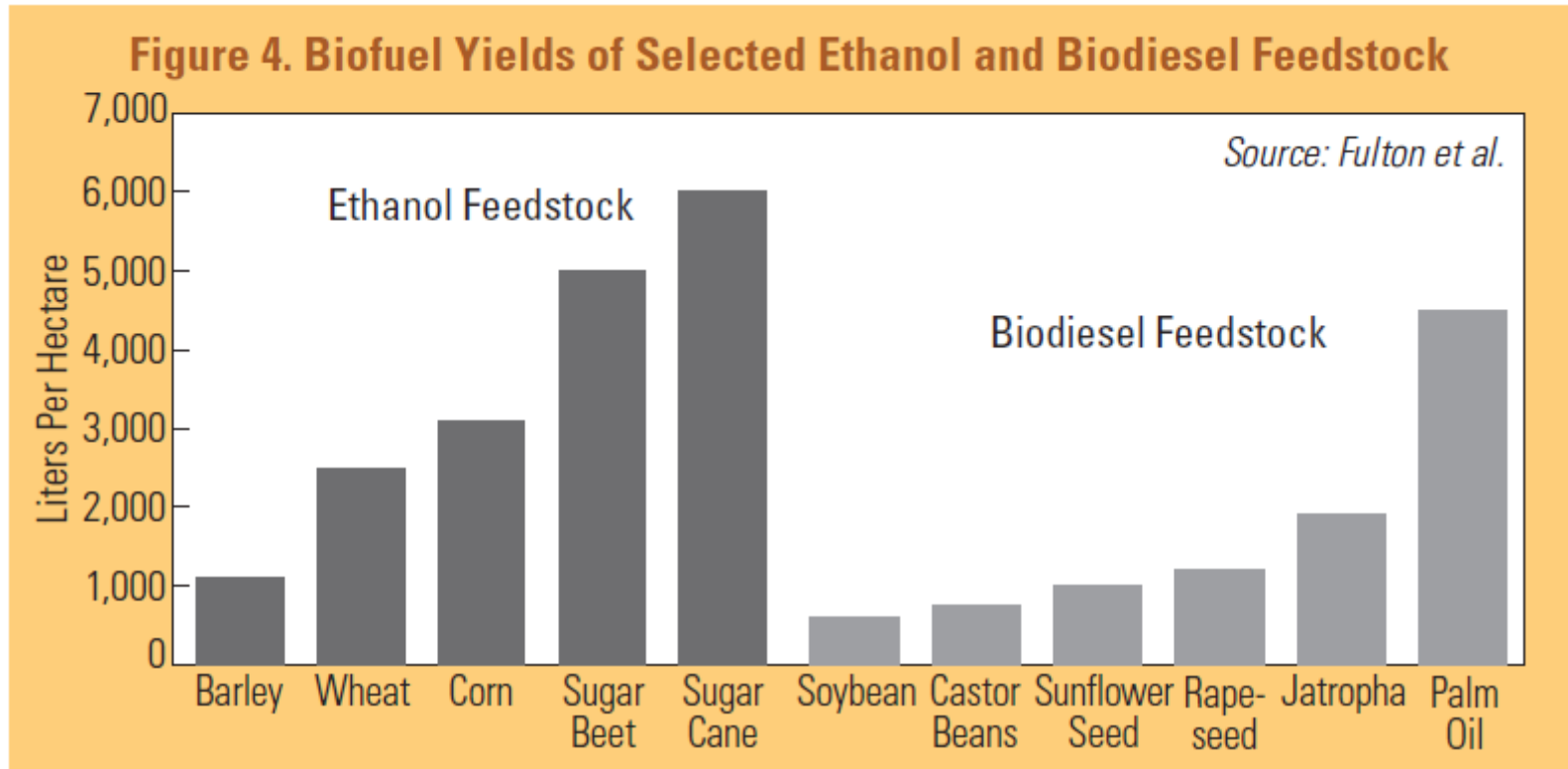
Is ethanol production from sugarcane sustainable?

**Which other sources can complement ethanol?**

What are the challenges and opportunities for the future?



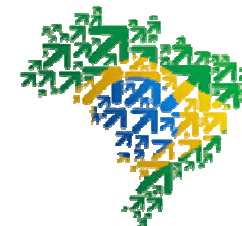
## Other Alternative Biofuels in Brazil - Biodiesel -



Brazil has around 100 potential oil plants in the Cerrado and Amazonia Biomes that can be developed as oil crops for biodiesel production



# Biodiesel Programs in Brazil



Challenge: developing new oil sources

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





# Biodiesel Programs in Brazil



Species under investigation for biodiesel production in Brazil

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



# Biodiesel Programs in Brazil

Public Policies to support development and use



## % 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 to biodiesel-petrodiesel mix





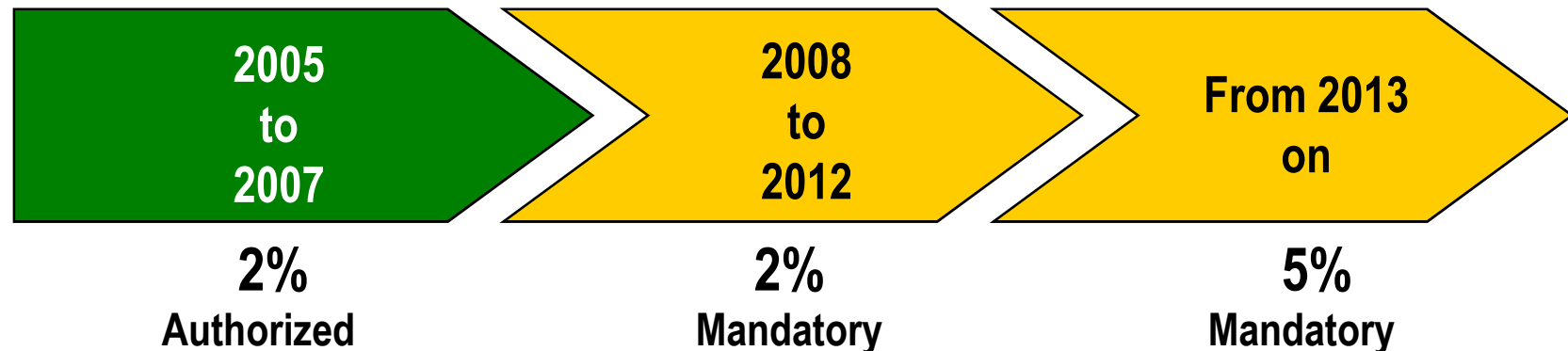
# Biodiesel Programs in Brazil

Public Policies to support development and use



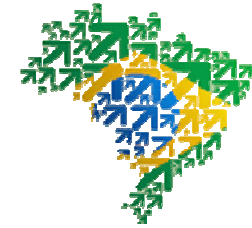
- 2002 Ministry of Science and Technology initiated ProBiodiesel
- 2004 National Program of Biodiesel Production and Use (PNPB)
- 2005 First biodiesel processing plant was established in Minas Gerais State

➤ 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.



# Renewable Energy in Brazil

## Challenges and opportunities



### Ethanol

- ✓ Improve Agricultural and industrial processes (burning, harvesting, waste...)
- ✓ 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

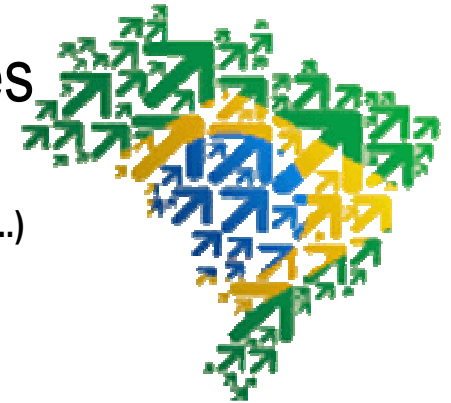
### Biodiesel

- ✓ 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

# Renewable Energy in Brazil

## Synthesis - Challenges and opportunities

- ✓ **Technology - efficiency & sustainability** (more with less area, water, energy,...)
  - ✓ **New alternatives and value addition to subproducts**
  - ✓ **Bagasse and waste gasification and hydrolisis**
  - ✓ **Industrial automation, fermentation process – yeast breeding**
  - ✓ **Precision agriculture, new inputs, genetically modified energy crops**
- ✓ **Implementing and perfecting the agroecological zoning**
- ✓ **Strategic Inteligence - market dynamics and trends - internal & external**
- ✓ **As a global market develops - Standards, certification and traceability**
- ✓ **Infrastrutture and logístics**
- ✓ **Comunicação e information**
- ✓ **Capacity building**



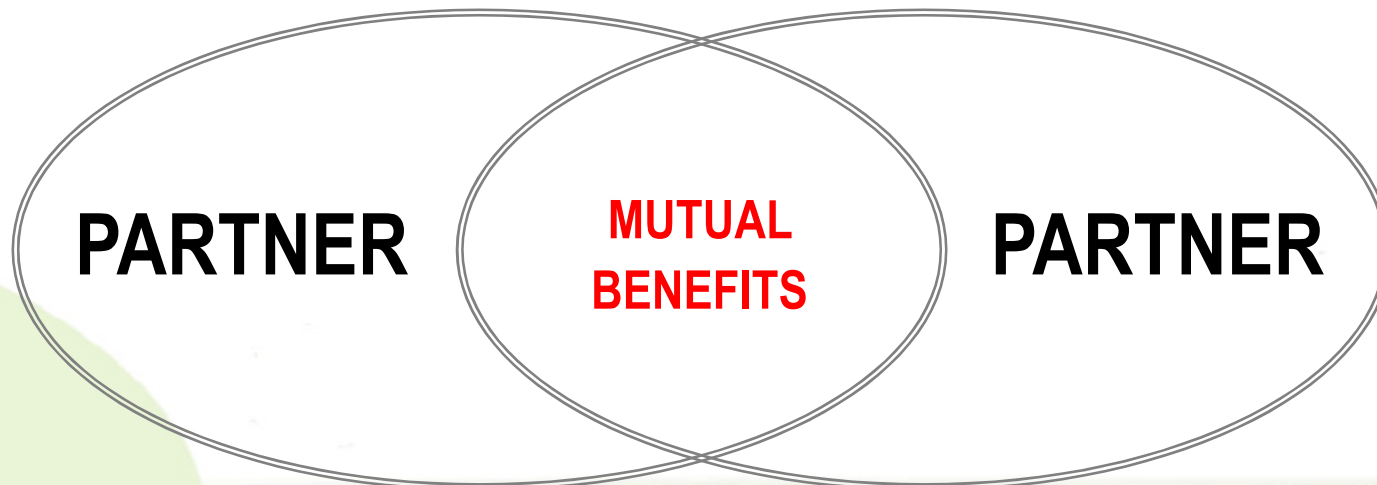




# Renewable Energy in Brazil

International Cooperation is a Priority

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





## Renewable Energy in Brazil

Many Institutions Dedicated to Renewable Energy R&D in Brazil

**Embrapa Agroenergy: [www.cnpae.embrapa.br/](http://www.cnpae.embrapa.br/)**

**The São Paulo State Research Foundation, FAPESP: [www.fapesp.br/english/](http://www.fapesp.br/english/)**

**FAPESP's Bioenergy Research Program (BIOEN): [bioenfapesp.org/](http://bioenfapesp.org/)**

**Sugarcane Planters Association, UNICA: [www.unica.com.br](http://www.unica.com.br)**

**Center for Sugarcane Research, CTC: [www.ctc.com.br](http://www.ctc.com.br)**

**Instituto Agronômico de Campinas – IAC [www.iac.sp.gov.br](http://www.iac.sp.gov.br)**

**+ Networks - Ridesa**

**+ Private companies - Alellyx, Canaviallis (Monsanto)**

**+ Universities,**

**Etc...**

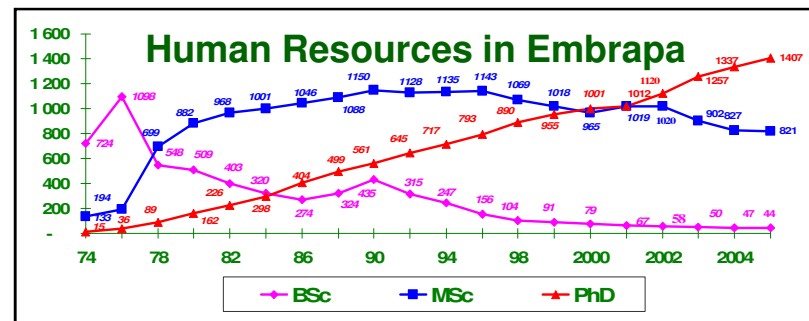
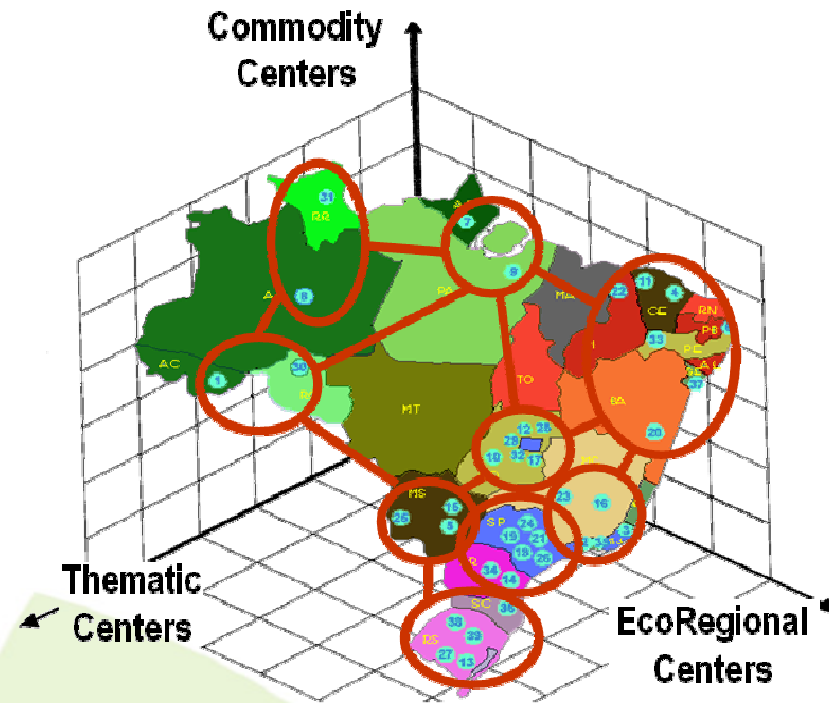




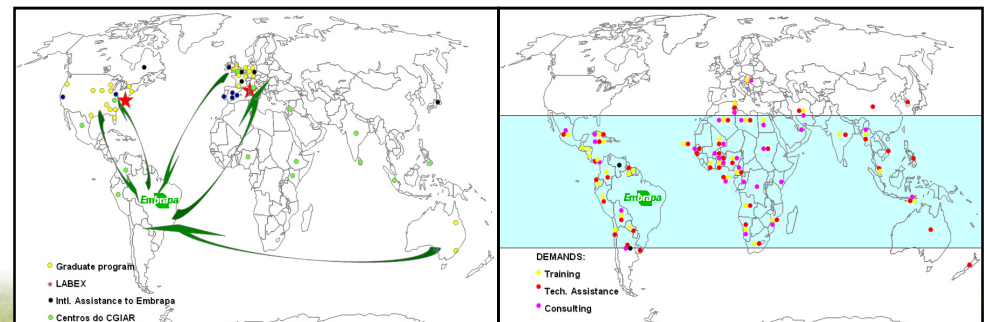
# Renewable Energy in Brazil

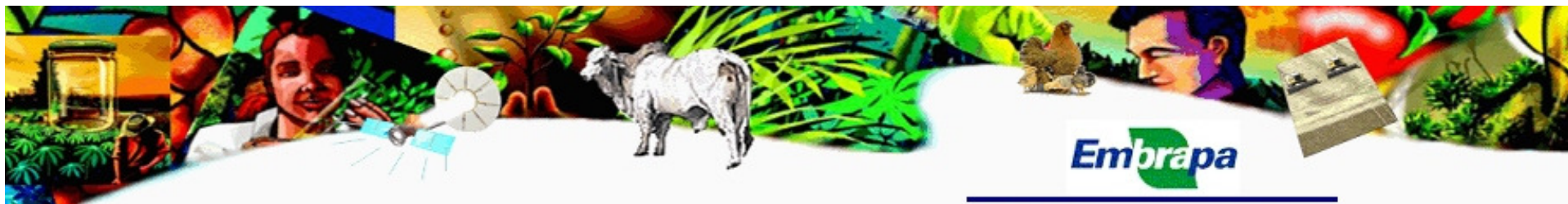
Brazilian Agricultural Research Corporation - Embrapa

## Embrapa Agricultural Research Network & Scientific Capacity



## The Network of International Cooperation





## **Embrapa Labex**

**A Program of international cooperation designed to promote opportunities for institutional cooperation in agricultural research and to monitor scientific advances, trends and activities of interest with partner countries in North America, Europe and Asia**







**Embrapa Labex Korea**

## **A partnership between Embrapa and RDA**

**Monitor Scientific and Technological Advances in Strategic Areas**

**Connect Brazilian and Korean (Asian) research groups and networks to develop collaborative research in genetic resources, animal sciences, advanced biology, bioenergy, agro-ecology, engineering / automation, etc.**

**Identify and promote opportunities for exchange of scientists and students**





# Thank You - 감사합니다

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