



# **SimbioCity - Fórum de sustentabilidade Brasil - Súécia**

## **BEST PROJECT AND THE EXPANSION OF THE ETHANOL SECTOR IN BRAZIL**

**José Roberto Moreira**

**National Reference Center on Biomass CENBIO**

**Institute of Electrotechnology and Energy –  
University of São Paulo**

**São Paulo, March 24-25, 2009**



**Urban and Agricultural residues**



**BRAZILIAN REFERENCE  
CENTER ON BIOMASS**



**Briquettes**



**Vegetables Oils**



**Sugarcane**



**Firewood and  
vegetable coal**

**Mission: Promote the efficient usage of biomass as source of energy in Brazil.**

# CONTENT

- 1) Bioethanol for Sustainable Transportation – BEST project description**
- 2) Technical and economic results from Brazilian experiment**
- 3) Impacts on the ethanol industry**
- 4) Bioelectricity growth**
- 5) Sugar cane ethanol sustainability**

# BEST Project

- ❑ BEST Project aims to promote the ethanol usage, replacing diesel, in public urban transport in Brazil and worldwide;
- ❑ Beyond São Paulo, the pioneer city in America, eight cities in Europe and Asia take part in the project;
- ❑ The project is an European Union initiative, and it is coordinated by the Stockholm City Hall.

# Previous experiences

**1979 - Buses and trucks with Diesel engines fueled by ethanol.**



**1982-1987: Scania Truck**



**1980-1981 Bus fueled by ethanol**

# Review

**1985 – Tests started in Sweden.**



**1990 to 2007 - 600 operational buses**

# The ethanol bus in São Paulo



**Ethanol bus at the  
Municipal Theater.**

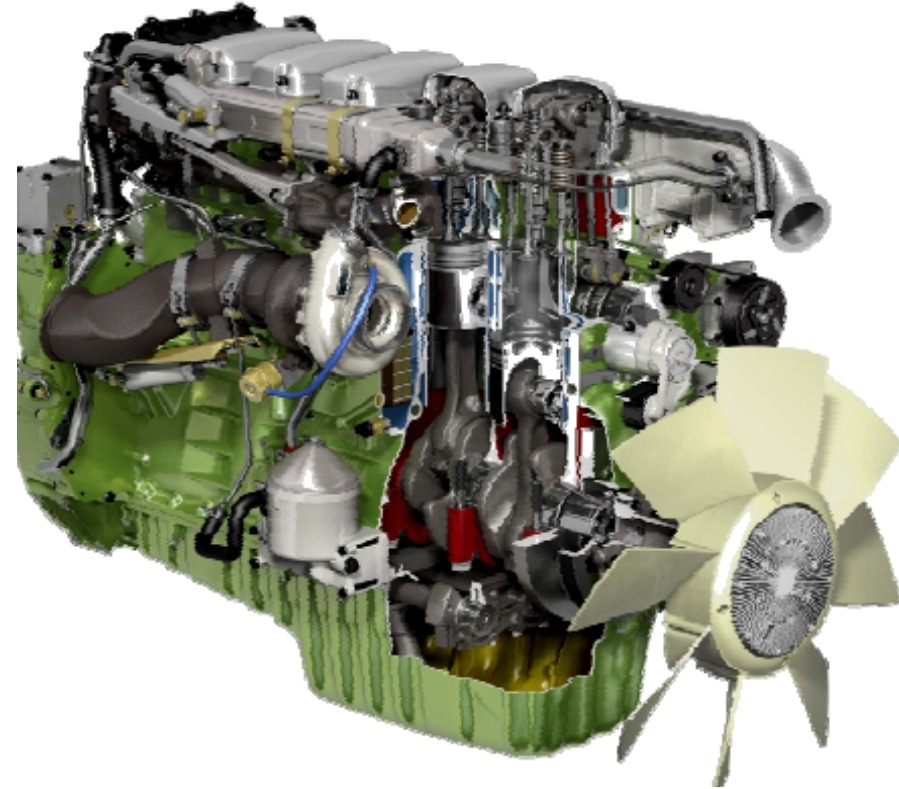
**January 25<sup>th</sup>, 2008**

**The 454<sup>th</sup> anniversary of São Paulo**



# Engine - Main differences

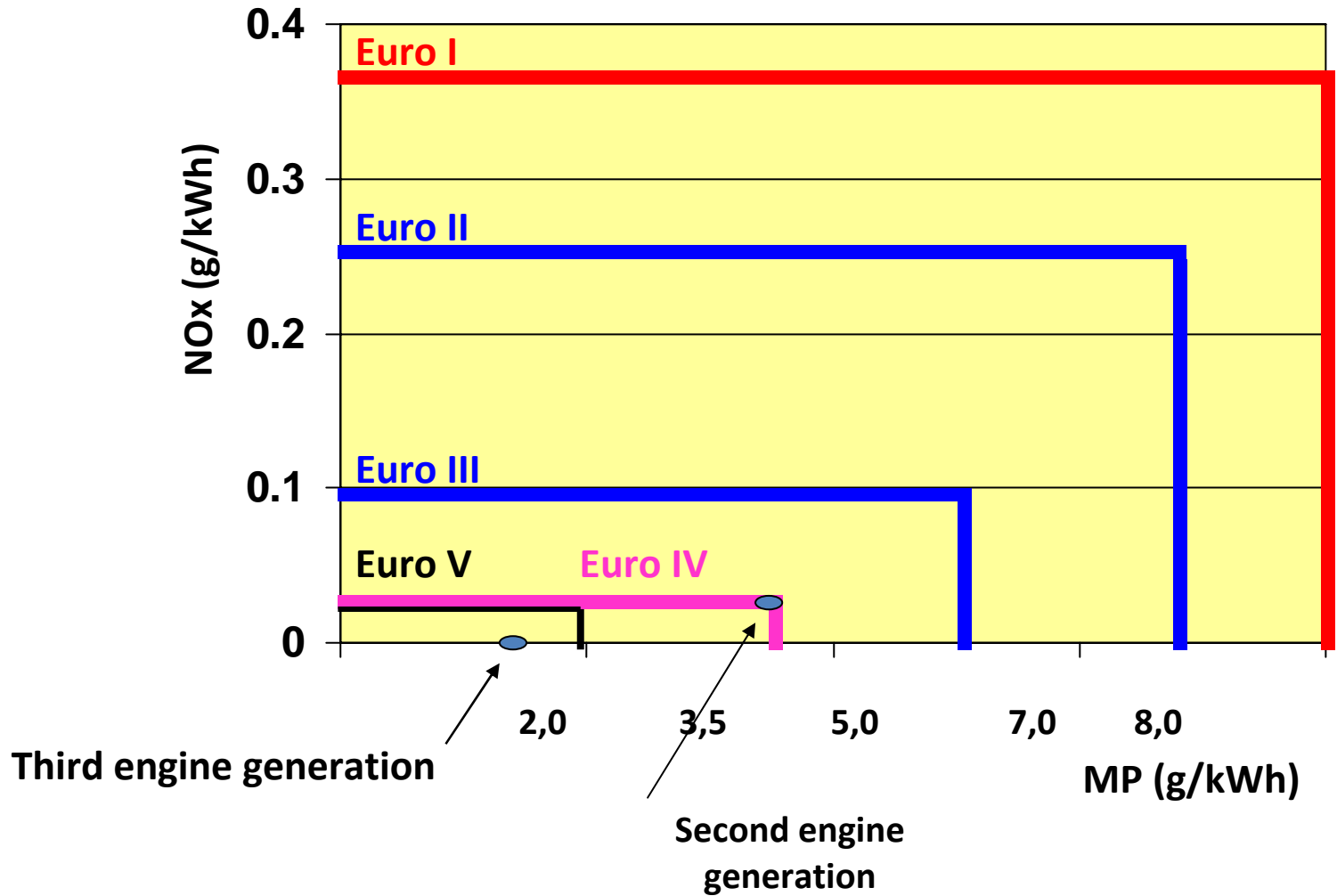
- ❑ Raised compression ratio 28:1(18:1);
- ❑ The same energetic efficiency as diesel;
- ❑ Larger flow fuel injectors, due to a lower ethanol energy contends in comparison to diesel;
- ❑ Materials resistant to ethanol;
- ❑ Attends to EURO 5 (European emission standard which will be validated in 2009) and EEV – Enhanced Environmental Vehicle.



\* The ethanol bus is equipped with the previous engine generation EURO4.



# Emission Limits for diesel engines



# Ethanol engine contribution to reduce pollutants

## Emissions reductions in comparison to diesel (CONAMA 5)

**CO: - 92%**

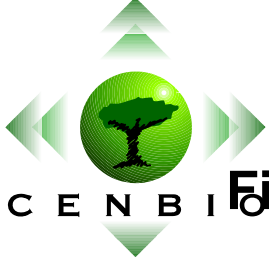
**MP: - 93%**

**HC: - 87%**

**NOx: - 52%**

**SOx: ~ 100%**

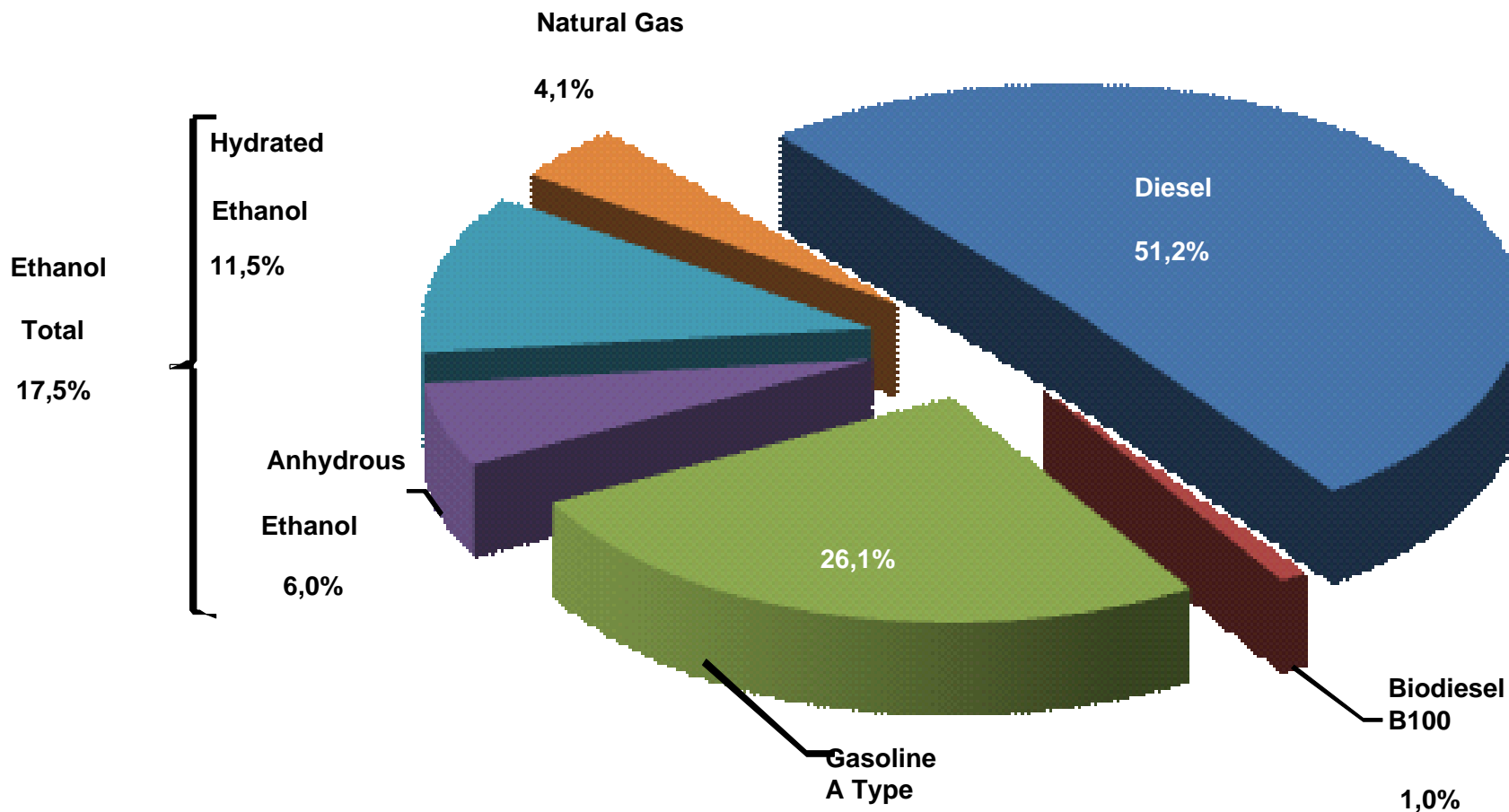
**CO<sub>2</sub>: ~ 100%**



C E N B I O

CENTRO NACIONAL  
DE REFERÊNCIA EM BIOMASSA

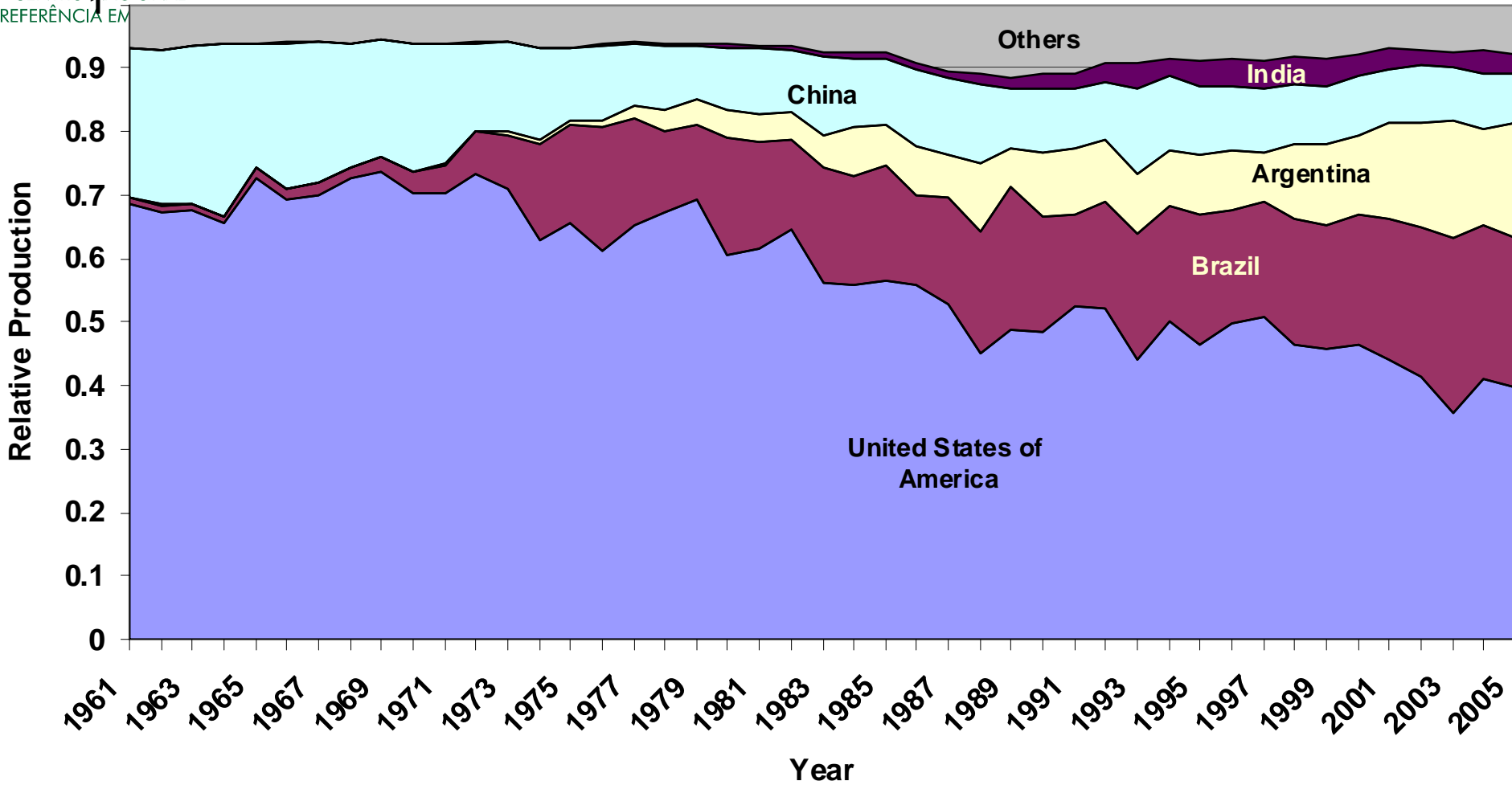
# First Semester 2008 – Brazilian Automotive Fuel Portfolio





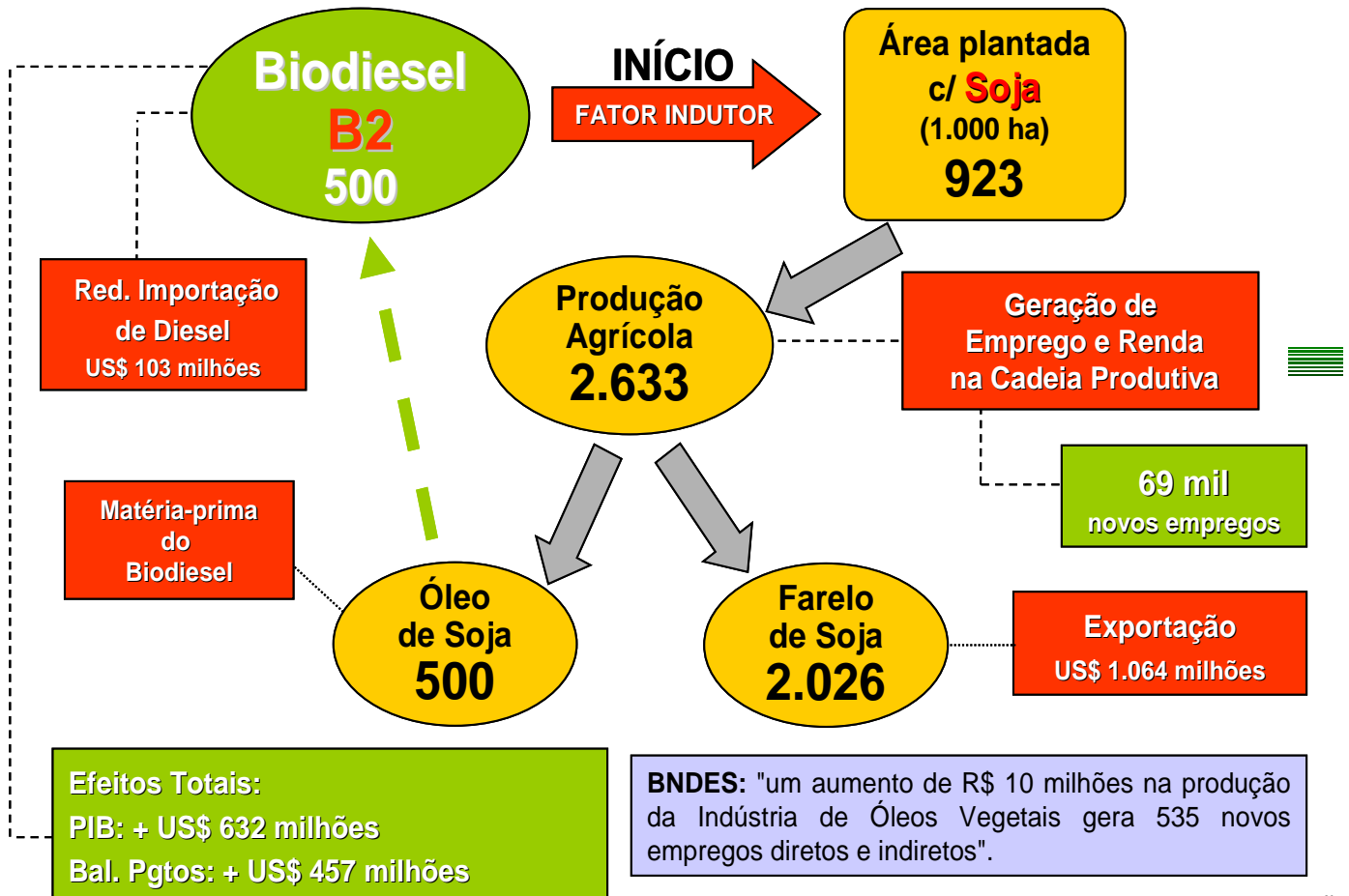
## Relative Soybean production - Major 5 Producers

CENTRO NACIONAL  
DE REFERÊNCIA EM



# BRAZIL: Biodiesel Production for the B2 Program in the South, Southeast and Middleast Regions

## Macroeconomic Impacts – Agrobusiness based in Soy (1.000 t)



## Brief report of fuel prices in São Paulo Site Source: ANP (2008).

Diesel price in São Paulo R\$/liter		Ethanol price in São Paulo R\$/liter	
<b>Retailer price</b>		<b>Retailer price</b>	
Sampling - 380 fuel stations		Sampling - 179 fuel stations	
Average diesel price	0.706 €	Average ethanol price	0.439 €
Minimum price	0.663 €	Minimum price	0.376 €
Maximum Price	0.750 €	Maximum Price	0.533 €
Standard deviation	0.021	Standard deviation	0.103
<b>Wholesale</b>		<b>Wholesale</b>	
Average diesel price	0.636 €	Average ethanol price	0.368 €
Minimum price	0.612 €	Minimum price	0.307 €
Maximum Price	0.662 €	Maximum Price	0.414 €
Standard deviation	0.035	Standard deviation	0.060
<b>Note: 1€ = R\$ 3.00</b>	<b>All the prices were converted to the European currency ( € )</b>		

[1] Source: Oil Agency – ANP. **Prices of Diesel in São Paulo**. Accessed in February 2009.

Available in: [http://www.anp.gov.br/preco/prc/Resumo\\_Por\\_Estado\\_Municipio.asp?cod\\_combustivel=643](http://www.anp.gov.br/preco/prc/Resumo_Por_Estado_Municipio.asp?cod_combustivel=643)

[2] Source: Oil Agency – ANP. **Prices of ethanol (álcool) in São Paulo**. Accessed in February 2009. Available in :

[http://www.anp.gov.br/preco/prc/Resumo\\_Por\\_Estado\\_Municipio.asp?cod\\_combustivel=997](http://www.anp.gov.br/preco/prc/Resumo_Por_Estado_Municipio.asp?cod_combustivel=997)

## Resume of months December 2008, January 2009.

<b>SCANIA DIESEL BUS</b>			
Month	Diesel (liters)	Driven distance (km)	Mileage (liters/km)
<b>December 2008</b>	3,488	4,651.5	0.750
<b>January 2009</b>	2,880	3,932.1	0.732
<b>February (not closed)</b>	1,043	1,458.0	0.714

<b>SCANIA ETHANOL BUS</b>				<b>Percentage higher than diesel (%)</b>
Month	E95 (liters)	Driven distance (km)	Mileage (liters/km)	
<b>December 2008</b>	4,886	4,039.4	1.210	<b>61%</b>
<b>January 2009</b>	4,708.8	3,947.6	1.193	<b>63%</b>
<b>February (not closed)</b>	1,890.2	1,575.5	1.200	<b>68%</b>

**Table 16: Simulation price of E95**

Price of the E95 liter (Simulation of price)	
<b>Proportion (BERAID/Ethanol)</b>	<b>kilograms of ethanol for each kilogram of 7.9 BERAID</b>
<b>Volume of ethanol</b>	<b>liters of ethanol (ethanol's density is 0.81kg/liter)</b>
<b>Price of BERAID in Sweden</b>	<div style="display: flex; align-items: center;"> <div style="background-color: blue; color: white; padding: 5px; margin-right: 10px;">\$ 18.20</div> <div style="font-size: 2em; margin-right: 10px;">→</div> <div style="background-color: green; color: white; padding: 5px; margin-right: 10px;">R\$ 5.06</div> <div>Price of a kilogram of BERAID in Sweden.</div> </div>
<b>Price of ethanol in Brazil</b>	<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;">R\$ 1,06</div> <div>is the wholesale price of a liter of ethanol</div> </div>
<b>E95 price</b>	<div style="display: flex; align-items: center;"> <div style="background-color: green; color: white; padding: 5px; margin-right: 10px;">R\$ 1.42</div> <div style="font-size: 2em; margin-right: 10px;">→</div> <div style="background-color: blue; color: white; padding: 5px; margin-right: 10px;">0.47 €</div> <div>Euro= R\$ 3.00</div> </div>

[1] Source: Price of the BERAID sold in Sweden. Information obtained by Professor Moreira.





C E N B I O

CENTRO NACIONAL  
DE REFERÊNCIA EM BIOMASSA

## Cost per driven kilometre simulated.

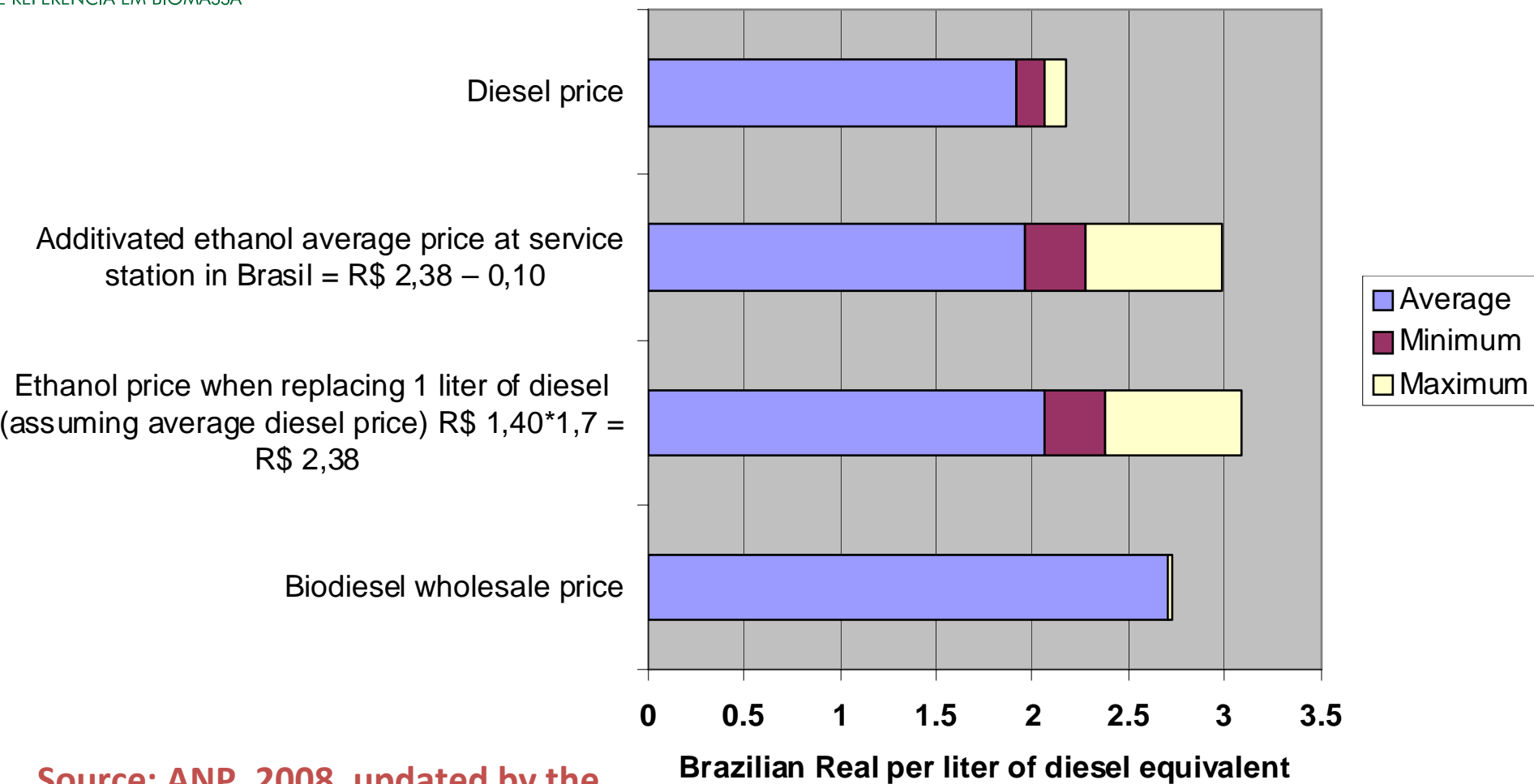
### PRICE SIMULATION SCANIA - ETHANOL BUS (4009) - BERAID considered in the price of the E95 liters

	Liters of E95	Driven distance (kilometers)	Average mileage (liters/kilometers)	Price of fuel (€/liter)	Monthly price of fuel	Maintenance	Cost (€/kilometer (only fuel cost))	Cost (€/kilometer (fuel and maintenance))
December 2008	4886.0	4039.4	1.210	0.47 €	2,310.617 €	- €	0.57 €	0.57 €
January 2009	4708.8	3947.6	1.193	0.47 €	2,226.818 €	306.70 €	0.56 €	0.64 €
February 2009	2190.3	1837.7	1.192	0.47 €	1,035.805 €	782.64 €	0.56 €	0.99 €
<b>Total</b>	<b>9594.8</b>	<b>7987</b>	<b>1.201</b>	<b>0.47 €</b>	<b>4,537.436 €</b>	<b>1,089.34 €</b>	<b>0.57 €</b>	<b>0.70 €</b>
<b>Percentage higher than diesel (only cost of fuel and maintenance cost considered)</b>						<b>%</b>	<b>19.65%</b>	<b>26.04%</b>



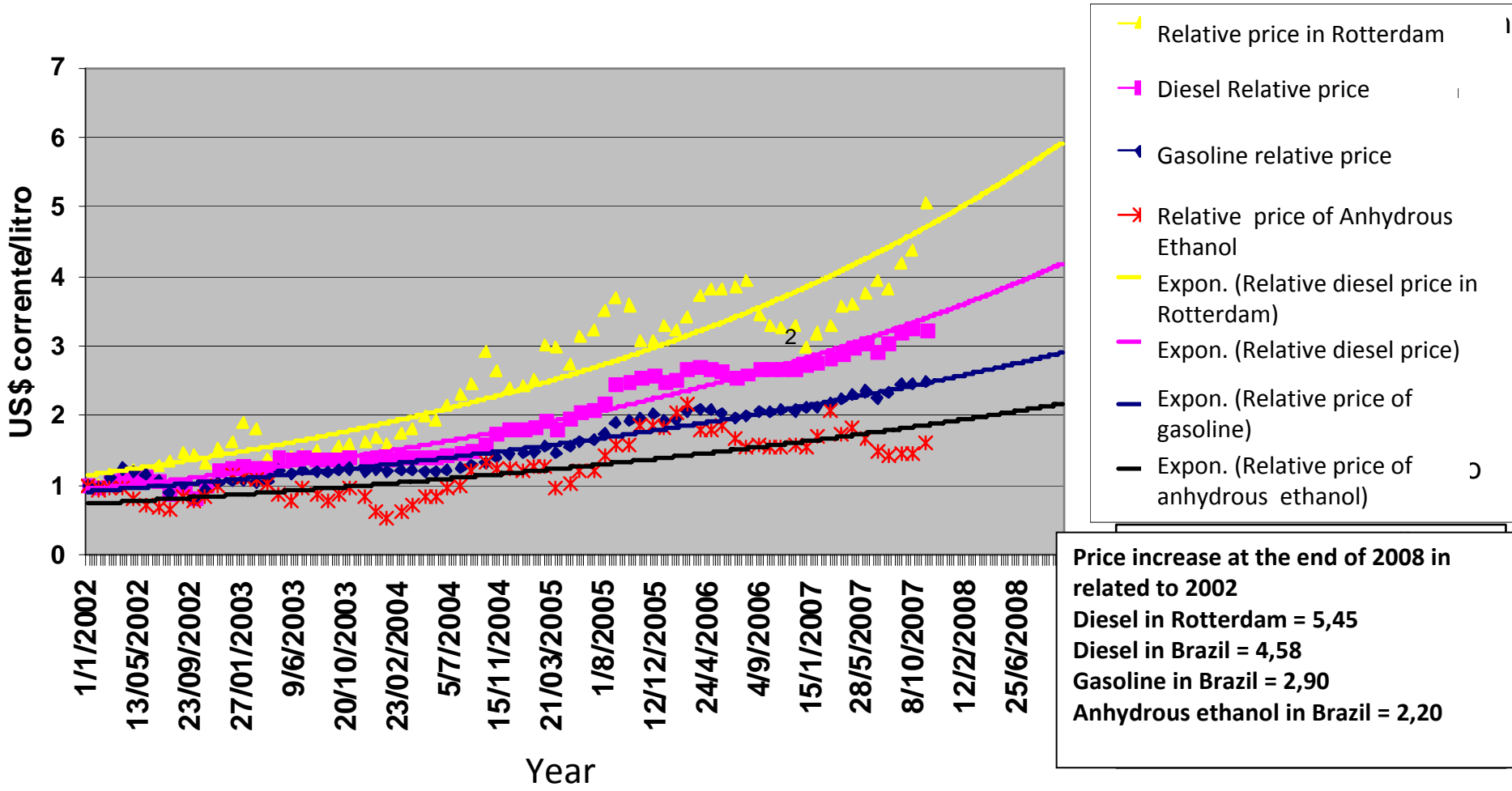
C E N B I O  
CENTRO NACIONAL  
DE REFERÊNCIA EM BIOMASSA

## Additivated Ethanol and Diesel Oil Prices at Service Stations, as well as Biodiesel at the Wholesale Market



Source: ANP, 2008, updated by the May-2008 adjustment.

# Relative prices in US\$ for gasoline , diesel and anhydrous ethanol- Brazil, and diesel in Rotterdam -2002-2007. Also the 2008 forecast in “Business as Usual”



**Impacts of additions of ethanol blends or Biodiesel at the final fuel costs and at the public transport costs are extremely low.**

<b>Eth. and Biodiesel Overprice related to Diesel %</b>	<b>B2 Program</b>		<b>B5 Program</b>	
	<b>Fuel Price</b>	<b>Transport price*</b>	<b>Fuel Price</b>	<b>Transport price*</b>
<b>5%</b>	<b>0.10%</b>	<b>0.035%</b>	<b>0.25%</b>	<b>0.08%</b>
<b>10% Add. Eth.</b>	<b>0.20%</b>	<b>0.070%</b>	<b>0.50%</b>	<b>0.17%</b>
<b>20%</b>	<b>0.40%</b>	<b>0.150%</b>	<b>1.00%</b>	<b>0.35%</b>
<b>30% Biodiesel</b>	<b>0.60%</b>	<b>0.225%</b>	<b>1.50%</b>	<b>0.52%</b>
<b>40%</b>	<b>0.80%</b>	<b>0.300%</b>	<b>2.00%</b>	<b>0.70%</b>

**\* The fuel usually represents 35% of the final cost of transport.**

	2007/08e	2015/16	2020/21
Produção cana de açúcar (milhões t)	495	829	1.038
Área cultivada (milhões ha)	7,8	11,4	13,9
<b>Açúcar (milhões t)</b>	<b>30,7</b>	<b>41,3</b>	<b>45,0</b>
<i>Consumo interno</i>	12,1	11,4	12,1
<i>Exportação</i>	18,6	29,9	32,9
<b>Etanol (bilhões litros)</b>	<b>22,3</b>	<b>46,9</b>	<b>65,3</b>
<i>Consumo interno</i>	18,7	34,6	49,6
<i>Excedente para exportação</i>	3,6	12,3	15,7
<b>Potencial Bioeletricidade (MWmédio)</b>	<b>1.800</b>	<b>11.500</b>	<b>14.400</b>
<i>Participação na matriz elétrica (%)</i>	3%	15%	15%

**Etanol + Bioeletricidade: safra 2007/08**



**2020/21 > + 5 vezes**

Nota: (a) produção Nordeste safra 2007/08 - estimada a partir dos dados disponíveis em abril/08

(b) potencial bioeletricidade - considerado utilização de 75% do bagaço + 50% da palha disponível

Elaboração: UNICA e Cogen-SP

# Bioeletricidade > Comercializada nos Leilões de 2005 a 2008

Leilão LEN – Energia Nova LFA – Fontes Alternativas LER – Energia de Reserva	Nº Projeto	MW Instalado	Garantia Física MW médio	Total Vendido MW médio	Preço Médio R\$/MWh	Preço Médio Corrigido R\$/MWh *
2005 - LEN A-3 e A-5	7	230	123	97	150,6	169,1
2006 - LEN A-3	6	188	89	70	135,1	149,3
2006 - LEN A-5	5	234	89	61	141,5	155,7
2007 - LFA	12	542	214	140	142,6	152,5
2008 - LER	31	2.385	859**	548	155,7	155,7
2008 - LEN A-3	0	0	0	0	-	-
2008 - LEN A-5	1	114	45	35	145,0	145,0
<b>Total</b>	<b>62</b>	<b>3.732</b>	<b>1.418</b>	<b>951</b>	<b>150,4</b>	<b>155,7</b>

Receita Total Bioeletricidade Vendida > Leilões 2005 a 2008 > R\$ 19,5 bi em 15 anos

Receita Total do Leilão de Energia de Reserva > R\$ 11,2 bi em 15 anos

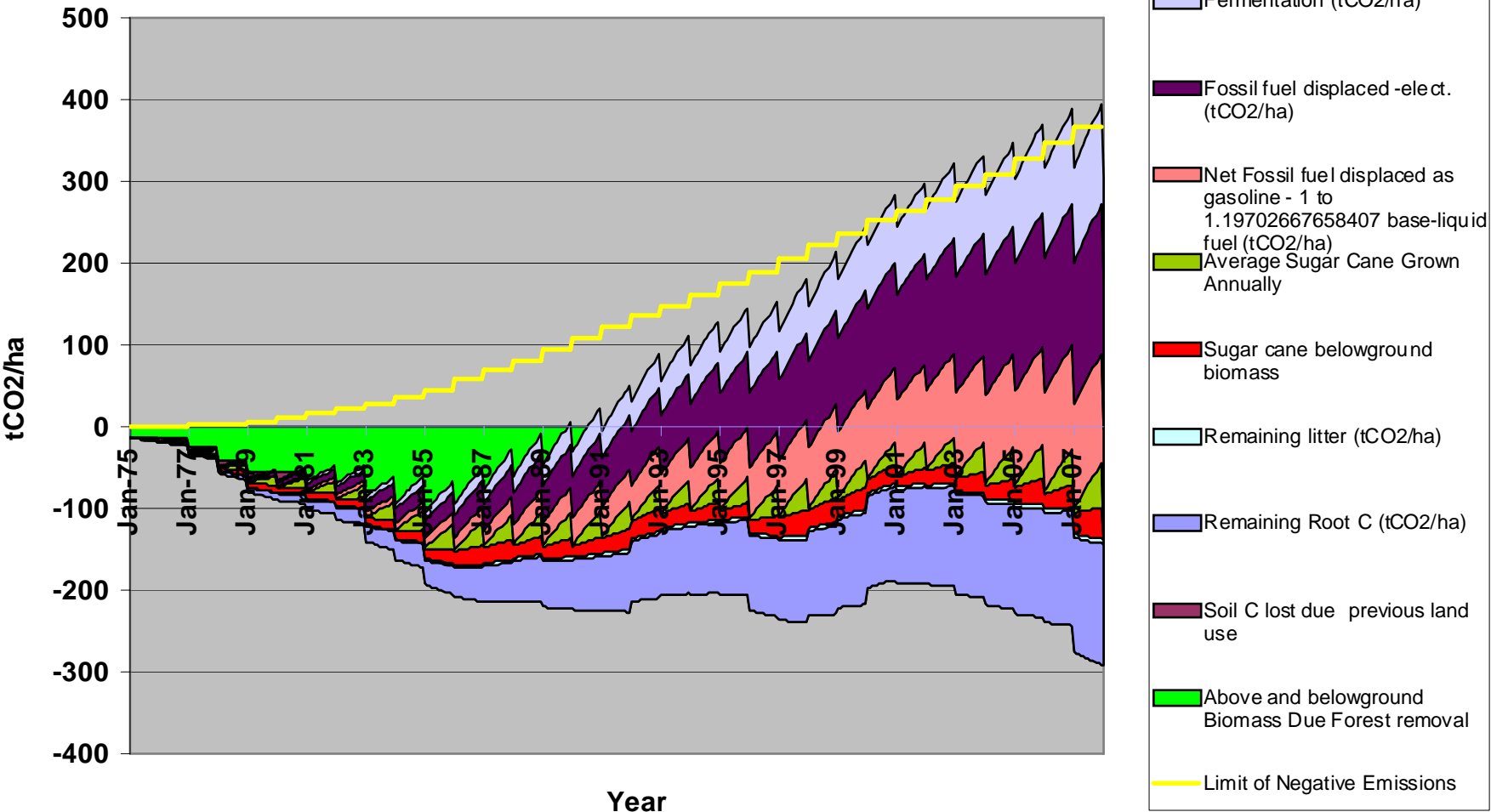
\*valor corrigido pelo IPCA    \*\* 311 MW médios para mercado livre

- **50% of Barbojo use**
- **Generation of 190 kWh/tcane from which 160 exported**
- **Previous intensity vegetation 20% of tropical forest**
- **N<sub>2</sub>O emission 1.325% of N applied at initial years and 2.7% at latter years**



# Sugar cane biomass and its potential CO<sub>2</sub> offsets - Proalcool Program in Brazil From 1975 to 2007 (32 years)

CENBIO  
CENTRO NACIONAL  
DE REFERÊNCIA EM BIOMASSA



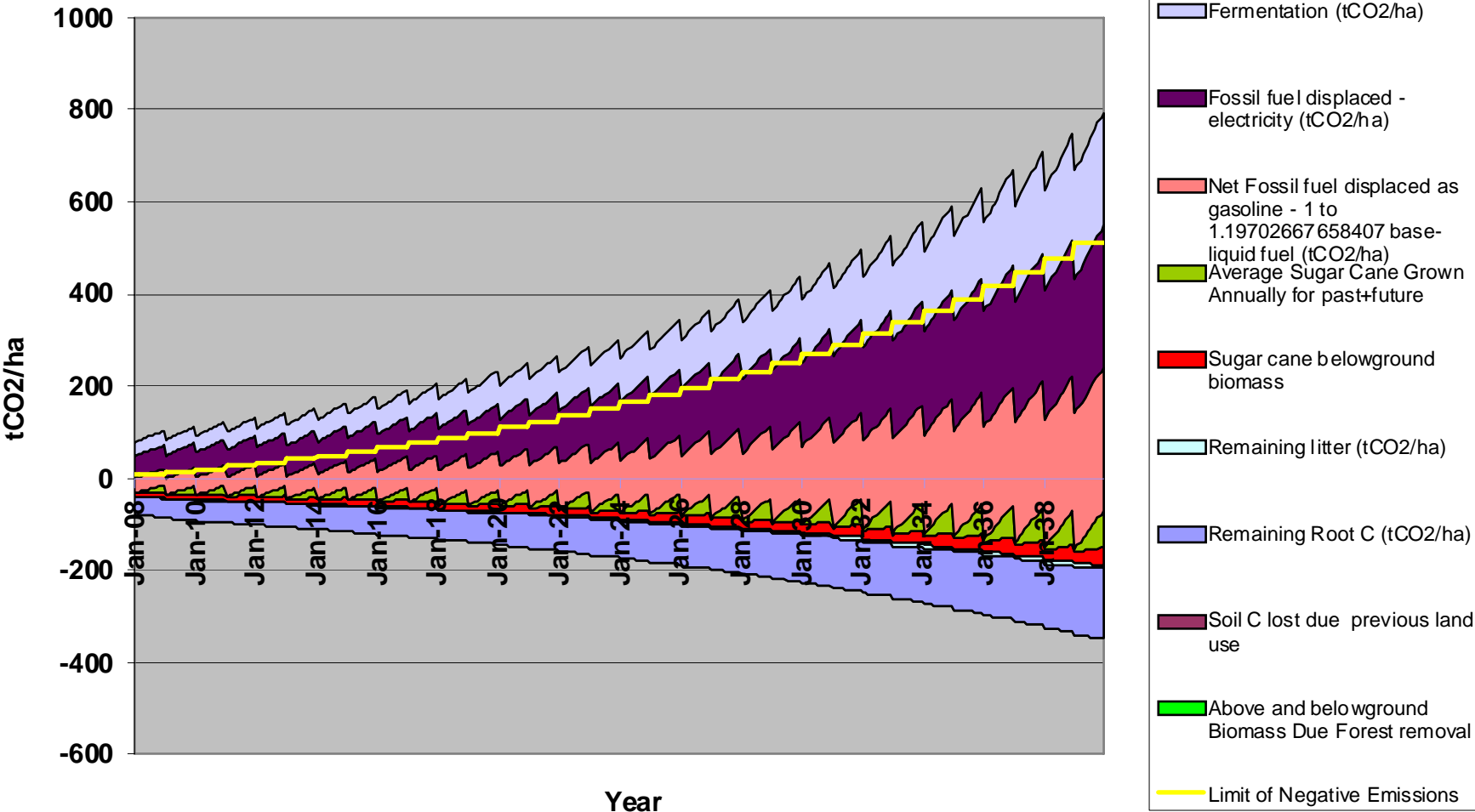




C E N B I O

# Sugar cane biomass and its potential CO2 offsets - Proalcool Program in Brazil From 2008 to 2039 (32 years)

CENTRO NACIONAL DE REFERÊNCIA EM BIOMASSA



**Table 2.1: Illustrative GHG savings and payback times for biofuel feedstock causing land change<sup>13</sup>**

Fuel chain	Assumed country of origin	GHG saving excluding the impacts of land-use change	Carbon payback (years)	
		%	Grassland	Forest
Palm to biodiesel	Malaysia	46%	0 – 11	18 – 38
Soya to biodiesel	USA	33%	14 – 96	179 – 481
Sugarcane to bioethanol	Brazil	71%	3 – 10	15 – 39
Wheat to bioethanol	UK	28%	20 – 34	80 – 140

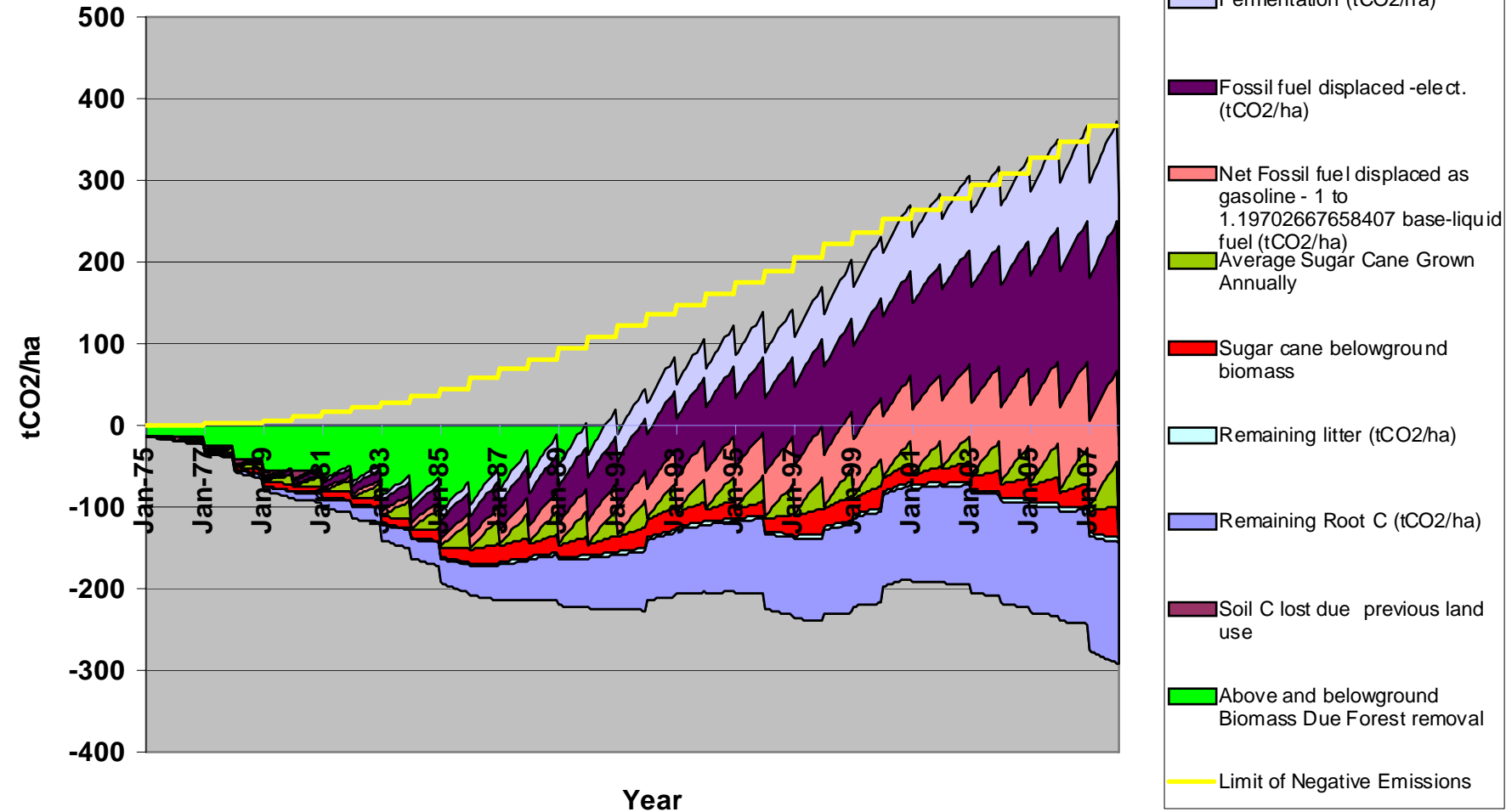
Source Gallagher Report, 2008

- **50% of Barbojo use**
- **Generation of 190 kWh/tcane from which 160 exported**
- **Previous intensity vegetation 20% of tropical forest**
- **N<sub>2</sub>O emission 2.7% of N applied at initial years and 4.0% at latter years**



# Sugar cane biomass and its potential CO2 offsets - Proalcool Program in Brazil From 1975 to 2007 (32 years)

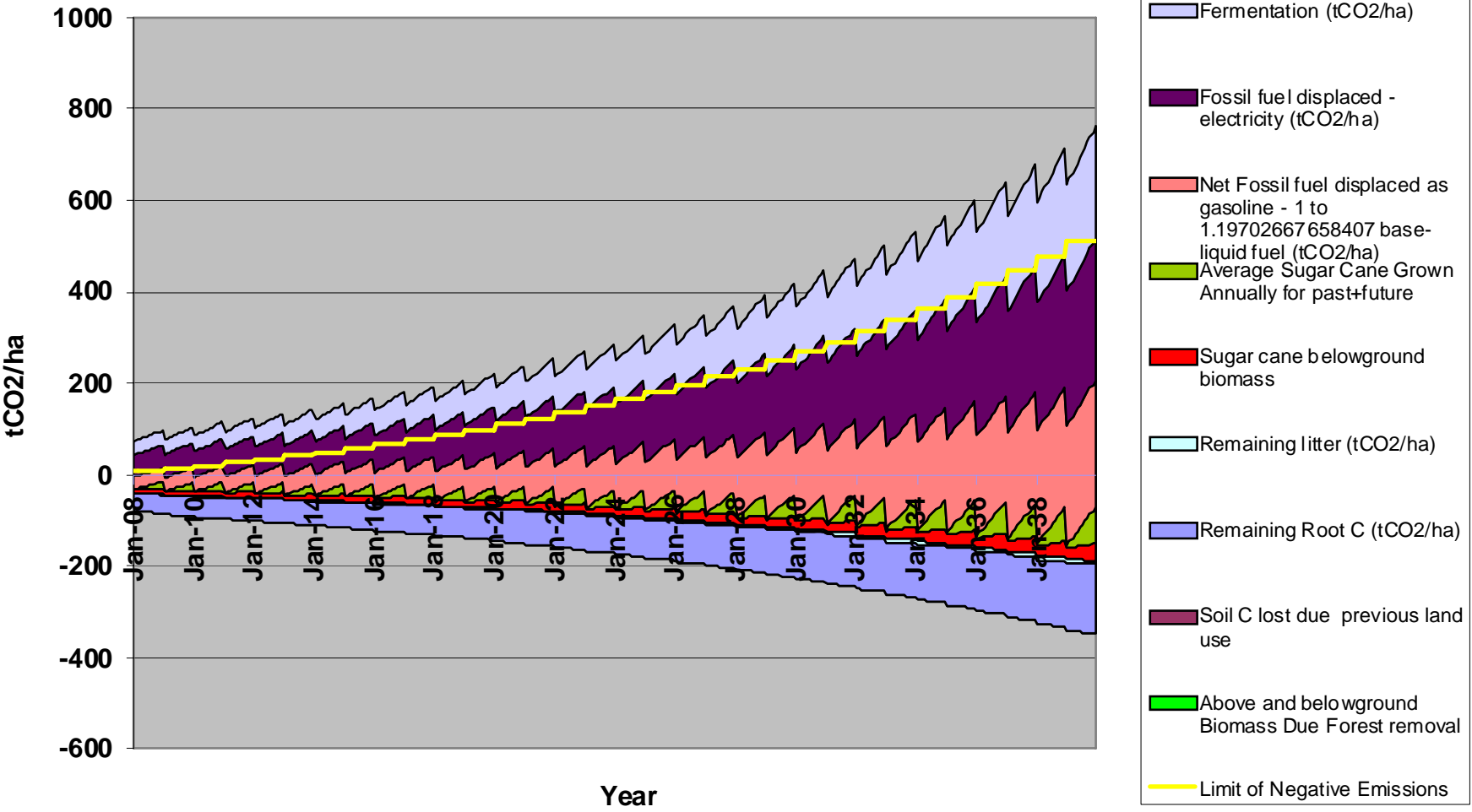
CENBIO  
CENTRO NACIONAL  
DE REFERÊNCIA EM BIOMASSA





C E N B I O  
CENTRO NACIONAL  
DE REFERÊNCIA EM BIOMASSA

# Sugar cane biomass and its potential CO2 offsets - Proalcool Program in Brazil From 2008 to 2039 (32 years)



# Advantages with the use of Ethanol in diesel type engines

- Ethanol is renewable, clean and biodegradable;
- Reduction on local air pollution: 90% for particulate matter and 62% for NOx;
- Fulfills EURO 5 and EEV – *Enhanced Environmental Vehicle*;
- Zero sulfur content, thus no impact on acid rain;
- 80% or more reduction on GHG emissions;
- Creates employments on rural areas;
- Is almost commercially feasible;
- Is immediately available in large amounts;
- Is fully compatible with existent liquid fuel distribution system;
- Is a national product.



# BEST

## BIOETHANOL FOR SUSTAINABLE TRANSPORT

**Obrigado!!!**

**Prof. Dr. José Roberto Moreira**

[cenbio@iee.usp.br](mailto:cenbio@iee.usp.br)

**Fone: (11) 3091-2650 / 3091-2652**