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EUBIA 2nd. Biomass Industry Day
Session 3 : Biofuels for Transport : Applications and Uses

Ethanol Powered Diesel Engines – Experience of Brazil

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Ethanol Powered Diesel Engines – Experience of Brazil

- History
- The Engine – Technical & Environmental Specifications
- Diesel Consumption and Displacement by Biodiesel
- Additivated Ethanol – Performance & Cost
- Opportunities in OECD Countries
- Conclusions

History

1979 – Acquisition of the first diesel engines buses and trucks powered with additivated alcohol in Brazil

1982-1987 “Treminhão”

1980-1981 Cometa Bus

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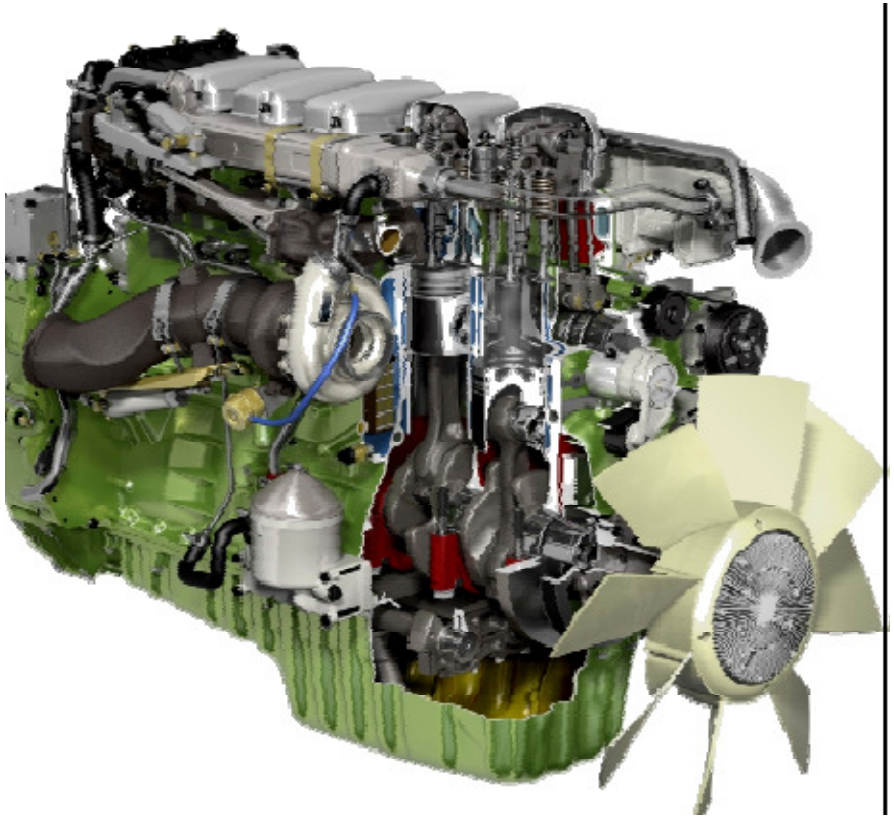
History

1985 – First tests with ethanol buses in Sweden

1990 to 2007 - 600 buses in operation

Motor – Major Differences

- Compression Ratio 28:1 (18:1);
- Same energy efficiency than regular diesel engine;
- Larger fuel injection volume due smaller ethanol low heating value;
- Few parts adapted to the use of ethanol;
- Fulfill EURO 5 regulation that will be effective by 2008 in Europe and EEV – *Enhanced Environmental Vehicle* (even more strong regulation which has no forecast to be introduced in Europe.



* Present motor under use in Brazil fulfills EURO 4, which will be effective in 2009..

ETHANOL BUSES

What is an ethanol bus?

An ethanol bus has a compression-ignition engine, a diesel engine, which is dedicated only for ethanol fuel. The chassis and the body are exactly the same as a normal standard bus for public transport.

What are the most important differences between an ethanol bus engine and a standard diesel bus engine?

An ethanol bus has some differences in the engine and in the fuel system compared to an equivalent diesel fulled bus.

Raised cylinder compression ratio. The compression ration in the cylinder is 1:22 for ethanol and 1:18 for diesel. That corresponds to a higher compression of 22 percentages.

.. Fuel pump with larger flow capacity. The ethanol fuel pump has higher capacity depending on higher fuel consumption.
. Larger injector holes.
. Modified injection timing.
. Gaskets and filters in the fuel system are exchanged to materials more resistant to alcohol. Since the ethanol fuel has up to five percentage of water all components also are resistant against corrosion.
. Maximum power for the ethanol engine is 169kW (230hp) at 1800-2000 rpm. Maximum power for the diesel engine is 191 kW (260 hp) at 2000 rpm. The engine power is 11,5% lower for the ethanol engine.
. The ethanol buses also have a sprinkler installation in the engine house.

EMISSIONS FROM BUS ENGINE EXHAUST SYSTEM WITH/WITHOUT POST-TREATMENT. DATA COMPARED TO THE EURO 4 AND EURO 5 EMISSIONS STANDARDS.

	(g/kWh)	
	NO_X	PM
European Emission Standard EURO 4 (2005)	3.5	0.02
European Emission Standard EURO 5 (2008)	2.0	0.02
(a) Ethanol engine without post-treatment	2.71	0.030
(b) Ethanol engine with catalyser	2.71	0.015
(c) Ethanol engine with catalyser and filter	2.76	0.003
(d) Ethanol engine with catalyser and 40% reduction as required by EEV standard. Without filter	1.57	0.0018
(e) Ethanol engine with catalyser and 40% reduction as required by EEV standard. With filter	1.60	0.0010

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Ethanol in Diesel Engines – Local Pollution

Emission reduction compared to equivalent Diesel Buses (CONAMA Brazilian Regulation - Phase 5)

CO: - 92%	**MP: - 93%**
HC: - 87%	**NOx: - 52%**
SOx: ~ 100%	**CO_2: ~ 100%**

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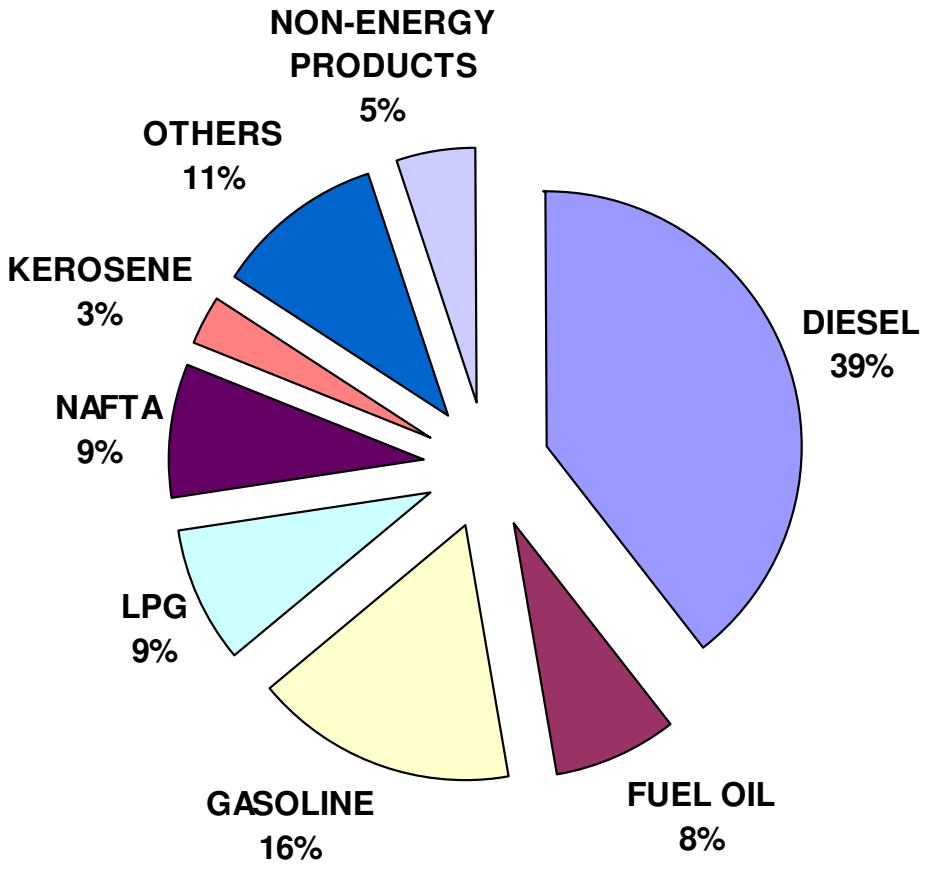
RELEVANCE OF DIESEL OIL DISPLACEMENT - BRAZIL

OIL DERIVATIVES CONSUMPTION - 2004



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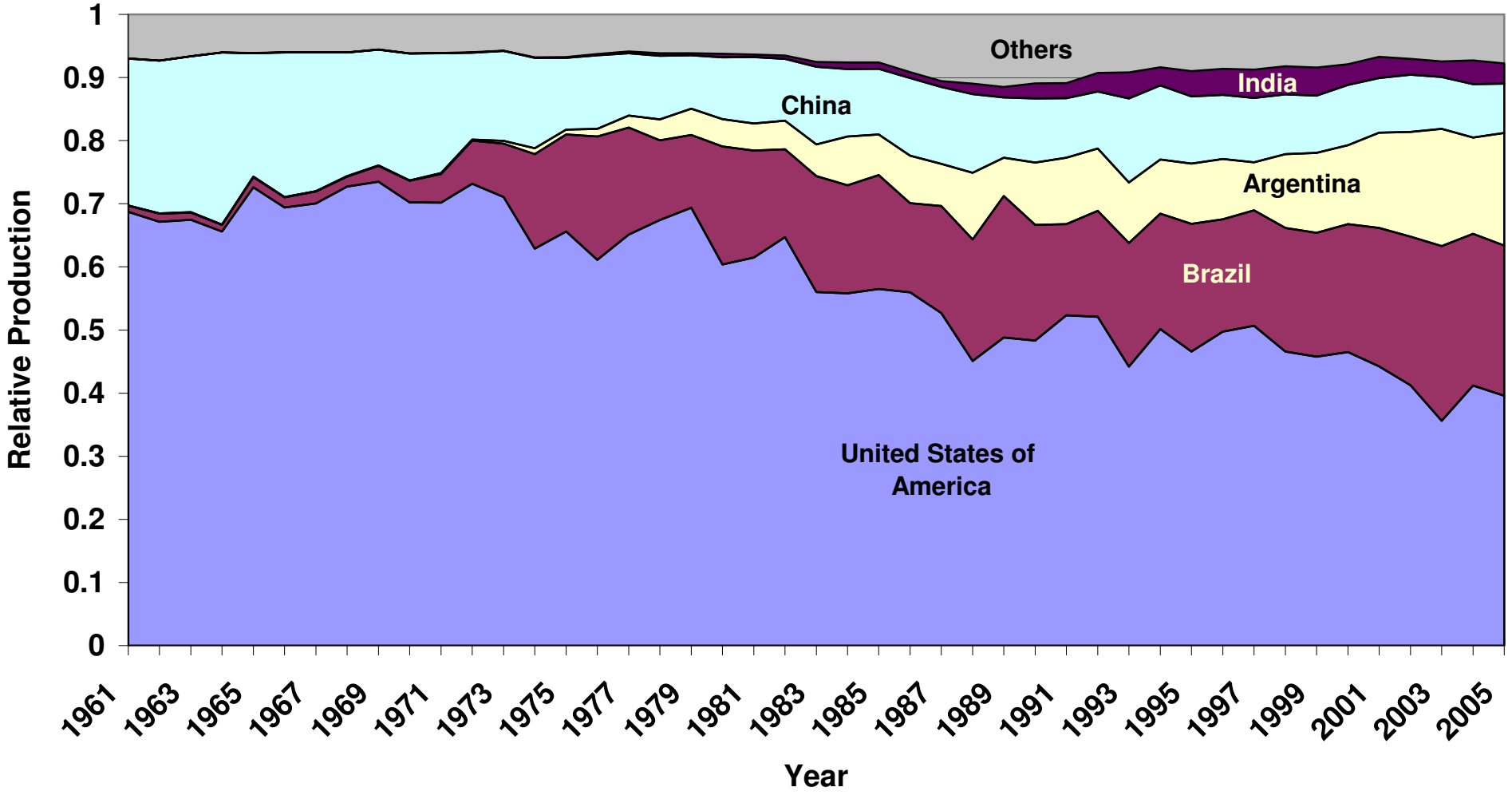
Relative Soybean production - Major 5 Producers



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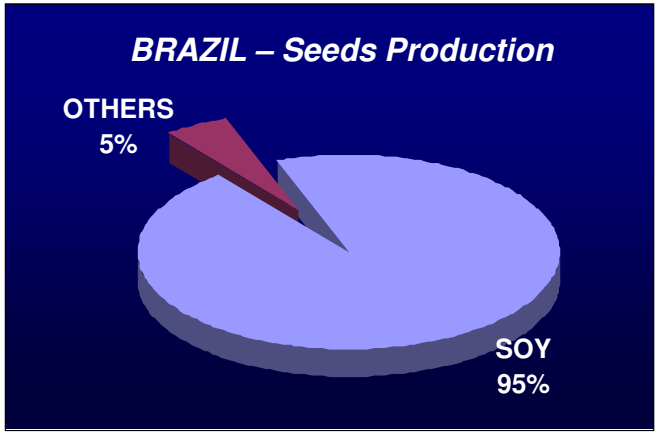
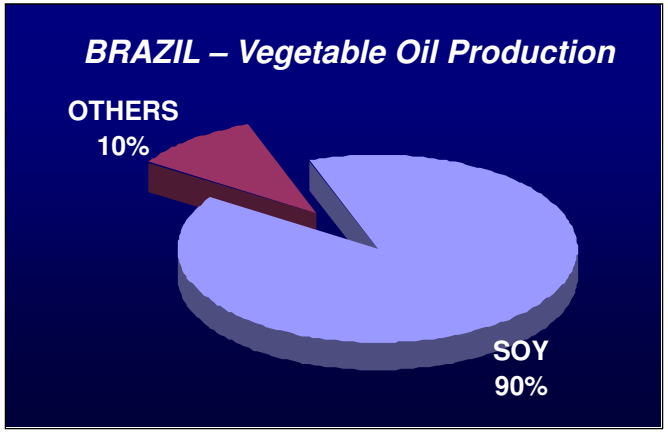
Production of Vegetable Seeds and Vegetable Oils - 2003

Crops	Seed (1.000 t)	%	Oil (1.000 t)	%
Soybeans	51,000*	*95.0*	5.613.2*	*89.8*
Cotton (seed)	2.133	*4.0*	256*	*4.1*
Palm Oil	N/A	*0.0*	134*	*2.1*
Sunflower	200*	*0.4*	75.8*	*1.2*
Castor	78	*0.1*	53.7*	*0.9*
Others	251	*0.5*	118.6	*1.9*
Total	**53,662**	***100***	**6,251**	***100***





Source: Oilworld - Oil World Annual 2004

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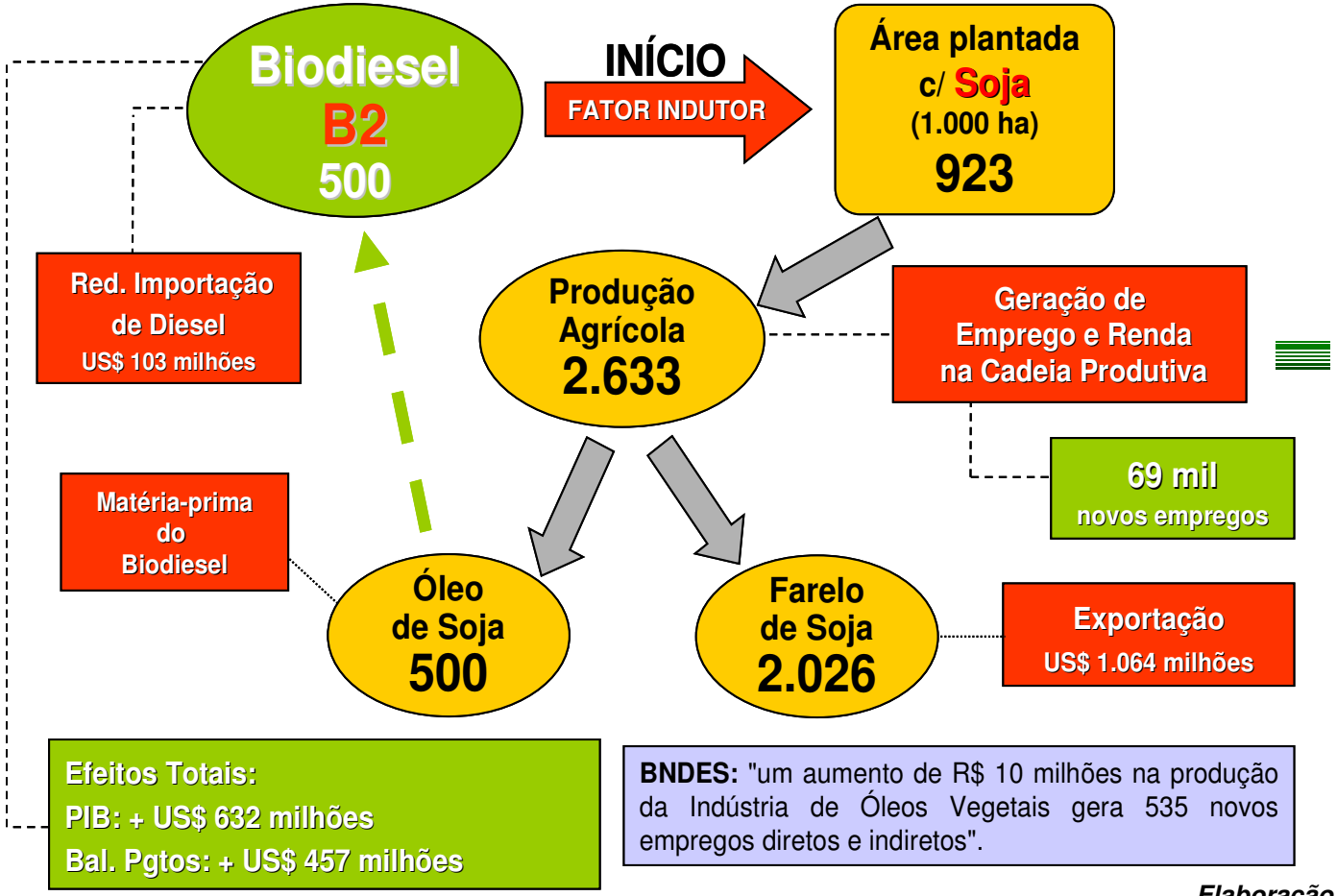
BRAZIL: Biodiesel Production for the B2 Program in the South, Southeast and Middleast Regions

Macroeconomic Impacts – Agrobusiness based in Soy (1.000 t)



Elaboração: ABIOVE

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Amount and price of imported diesel by Petrobras during the last five years, including 2008.

Year	Imported volume of diesel (m^3)	Import costs (million US$)
2008	Jan/Feb – 508,451	368.60
2007	5,099,406	3,019.51
2006	3,545,075	1,746.71
2005	2,371,306	1,019.64
2004	2,994,702	826.76
2003	3,818,362	791.12

Volume of diesel imported by Petrobras.
Source: ANP, 2008.

Bus w/ Diesel Motor Powered by Ethanol - Brazil

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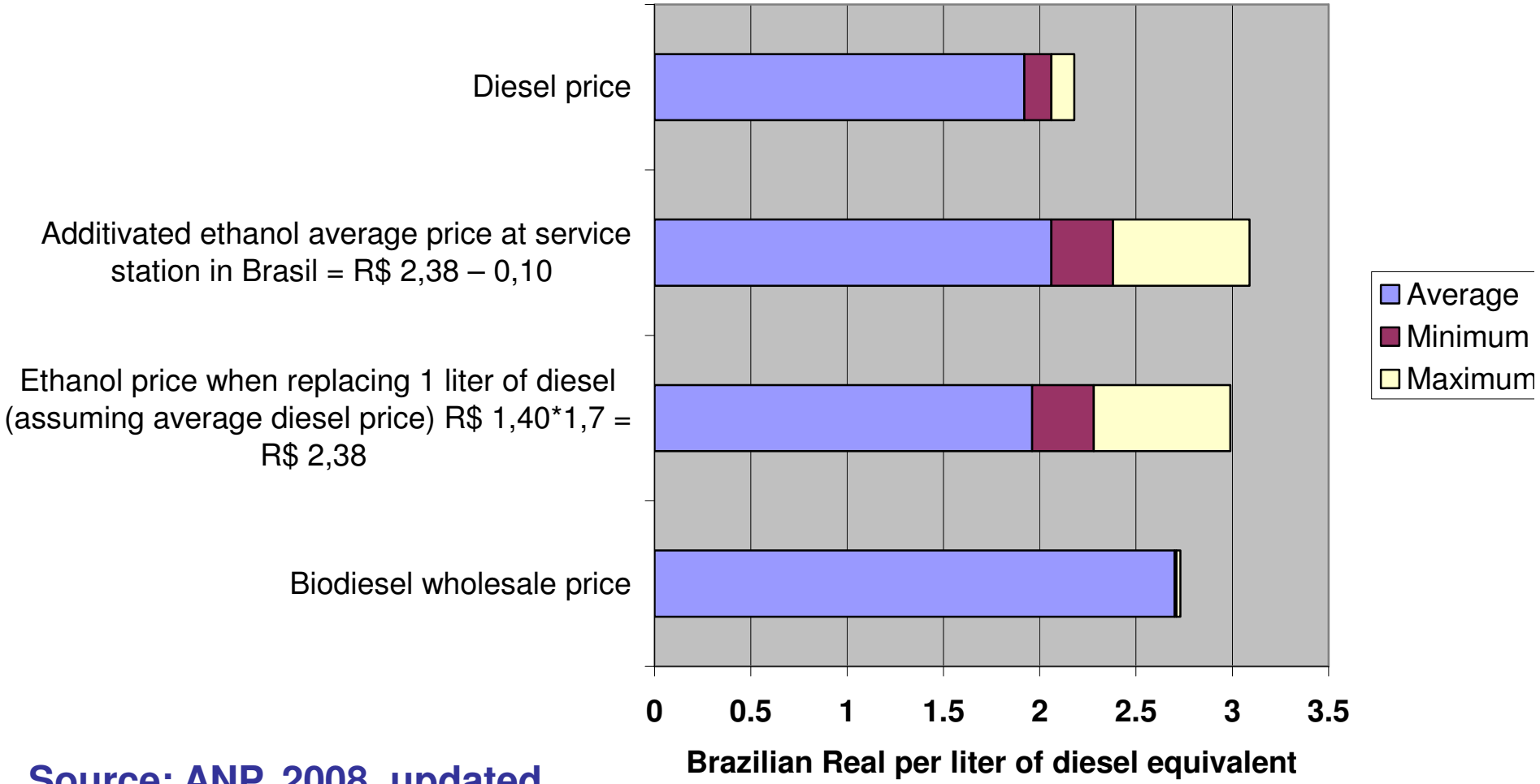
Additivated Ethanol and Diesel Oil Prices at Service Stations, as well as Biodiesel at the Wholesale Market



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

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INCIDENT TAXES: BIODIESEL PRODUCTION

TAXES	Biodiesel				Diesel Oil
	Family Farm in the North, Northeast and Semi-arid Castor/Palm Oil	Family Farm Other vegetable oil crops	Intensive Agriculture in the North, Northeast and Semi-arid Castor/Palm Oil	Other Producers	
	R$/liter	*R$/liter*	*R$/liter*	*R$/liter*	*R$/liter*
CIDE	Non-existent	Non-existent	Non-existent	Non-existent	**0.03**
PIS/COFINS	**100%** reduction in relation to other producers (R$ 0.0)	**68%** reduction in relation to other producers (R$ 0.07)	**32%** reduction in relation to other producers (R$ 0.151)	**0.222**	**0.148**
Sum of federal taxes	**100%** reduction in relation to other producers (R$ 0.0)	**68%** reduction in relation to other producers (R$ 0.07)	**32%** reduction in relation to other producers (R$ 0.151)	**0.222**	**0.218**

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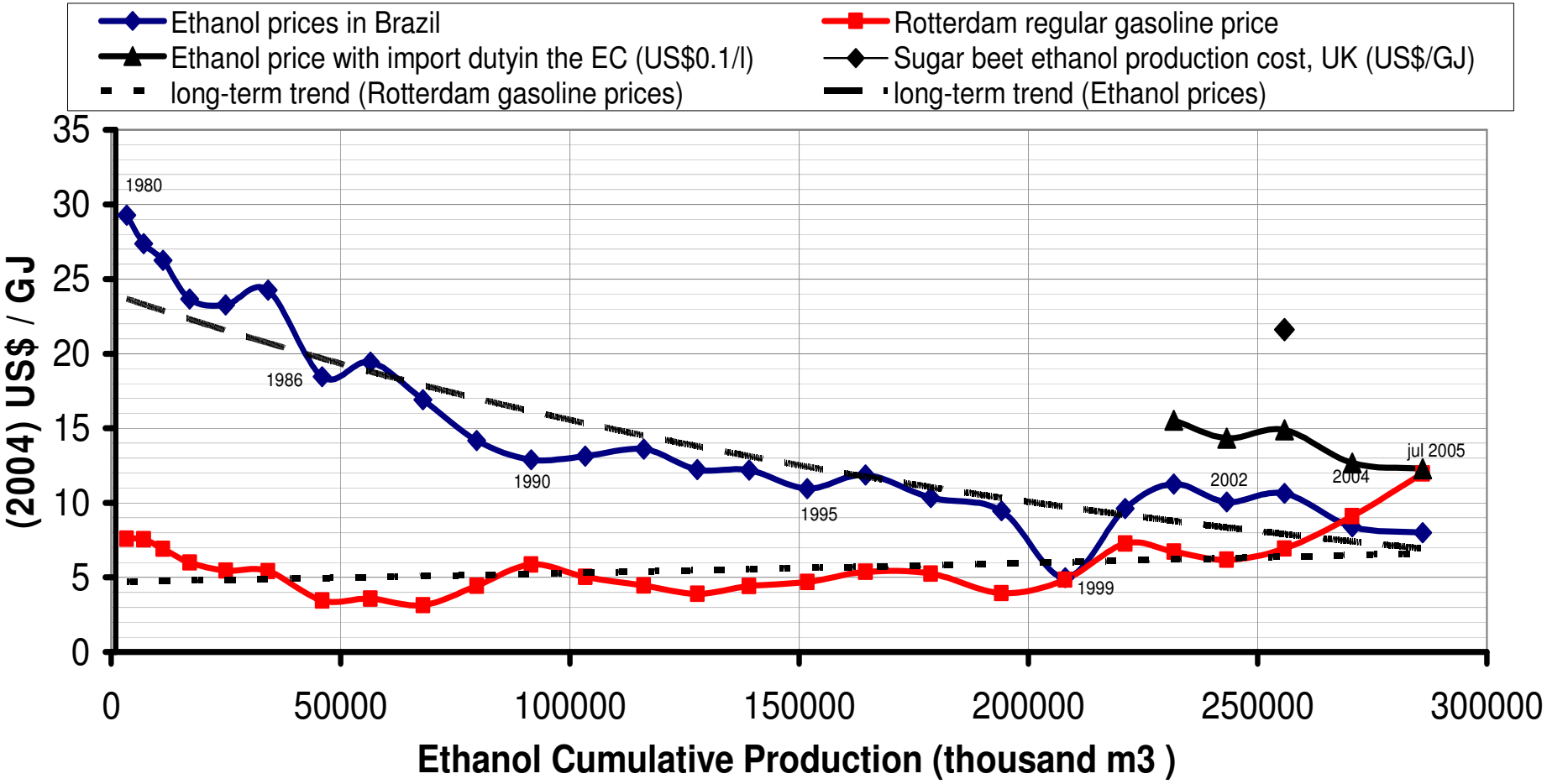
Economic Feasibility - Ethanol



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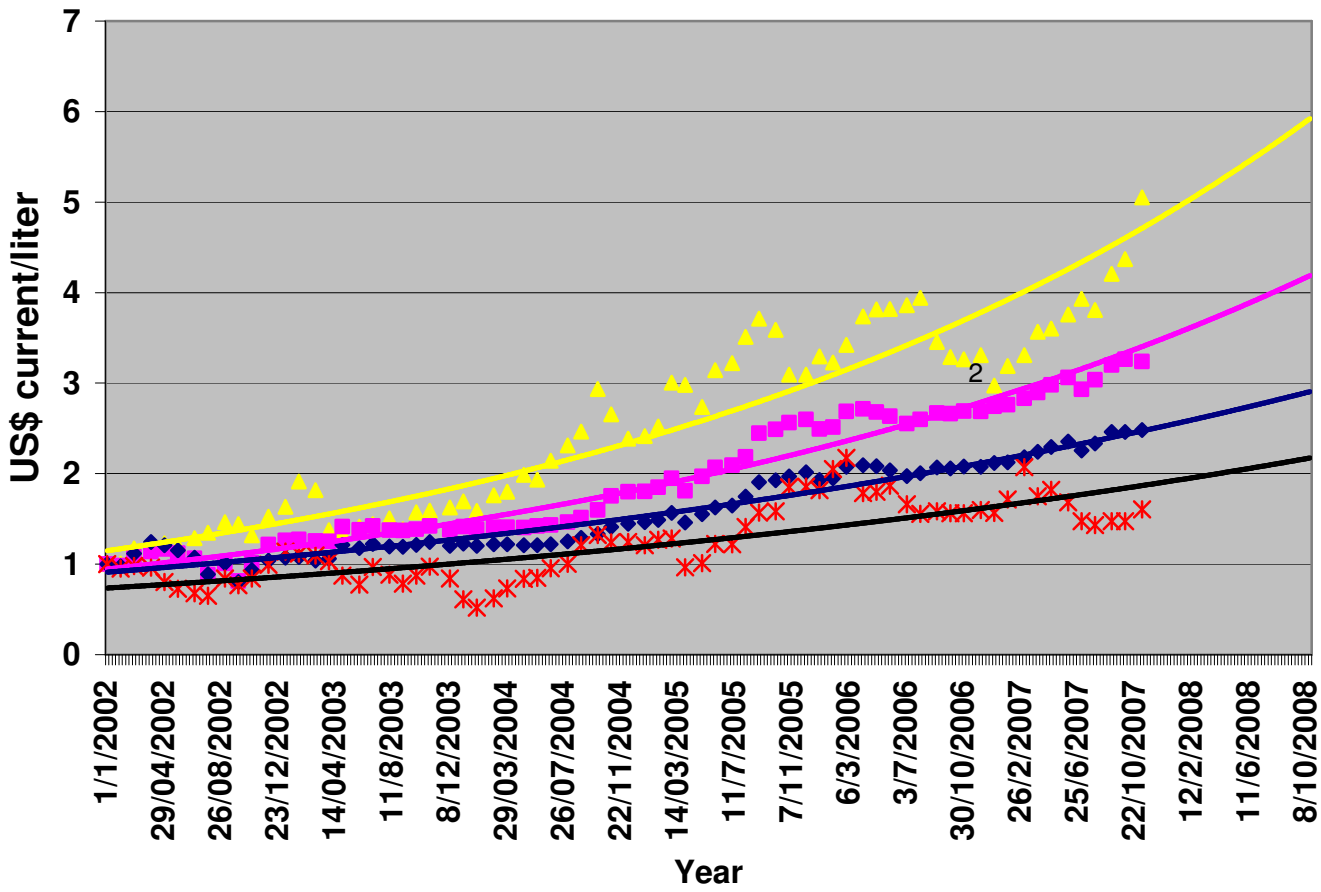
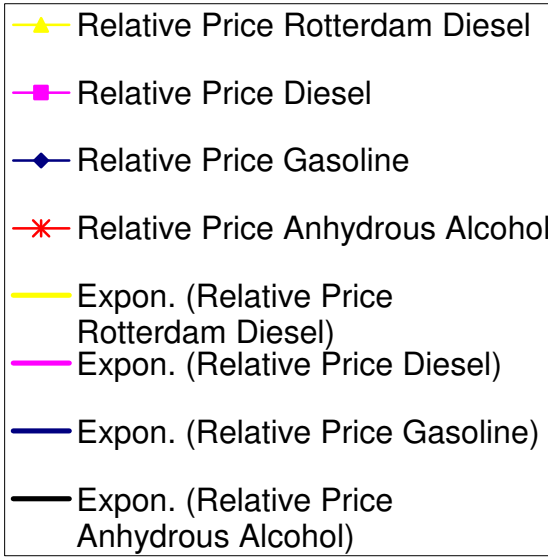
Relative Prices in US$ Current for Gasoline, Diesel, Diesel in Rotterdam and Anhydrous Alcohol - Brazil - 2002-2007 and Forecast for 2008 Assuming Business as Usual





Price Increase at end of 2008 relative to 2002

Diesel in Rotterdam = 5.45
Diesel in Brazil = 4.20
Gasoline in Brazil = 2.90
Anhydrous Alcohol in Brazil = 2.20

Impacts due the addition of Additivated Ethanol or Biodiesel in the final cost of fuel and in the public transportation cost is extremely low..

Add. Eth. or Biodiesel overprice relative to Diesel %	B2 Program		B5 Program	
	Fuel Price	Transport Price*	Fuel Price	Transport Price*
5%	0.10%	0.035%	0.25%	0.08%
10% Add. Eth.	0.20%	0.070%	0.50%	0.17%
20%	0.40%	0.150%	1.00%	0.35%
30% Biodiesel	0.60%	0.225%	1.50%	0.52%
40%	0.80%	0.300%	2.00%	0.70%

* Typically fuel represents 35% of total transportation cost

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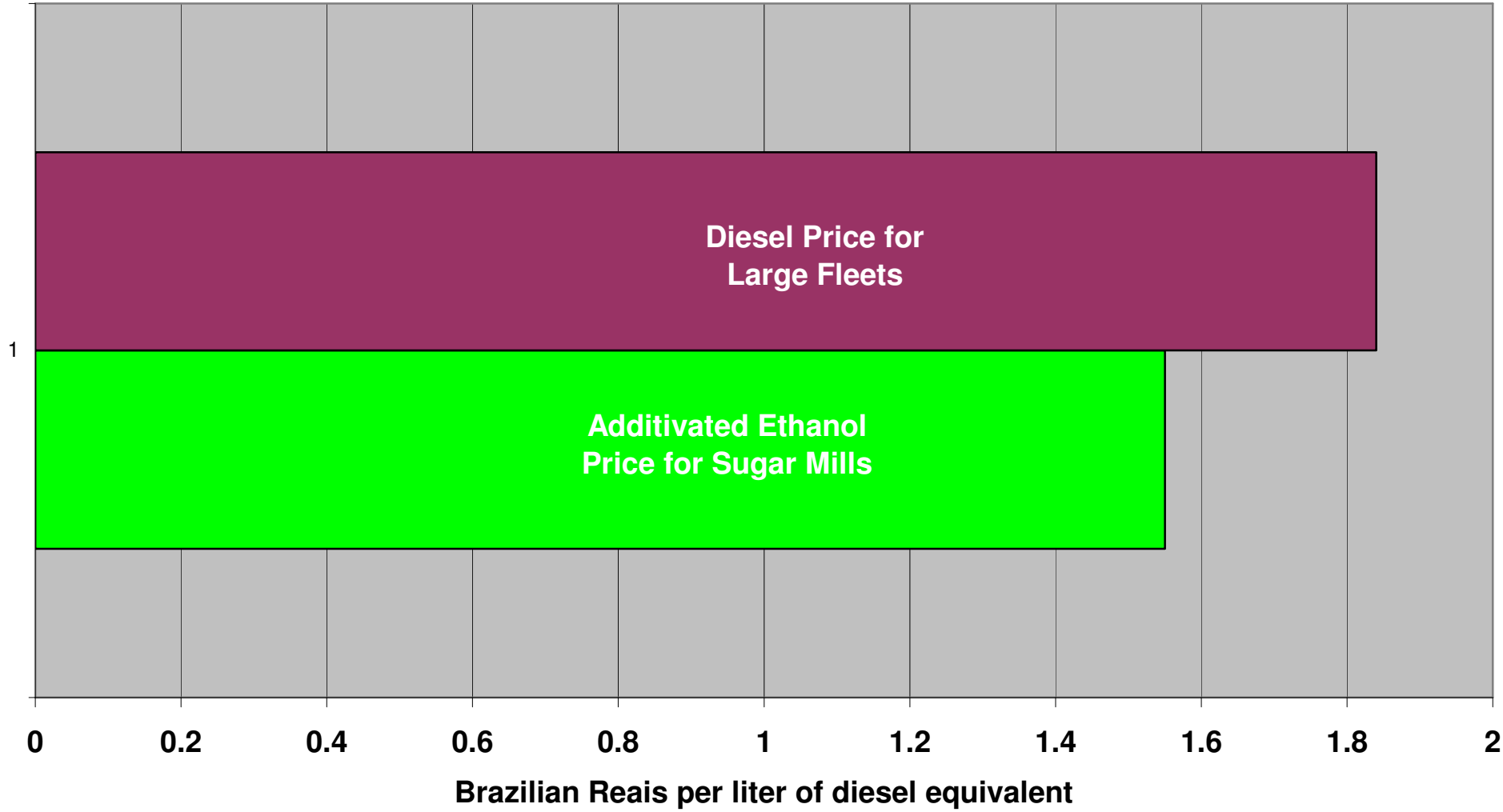
Additivated Ethanol and Diesel Wholesale Prices

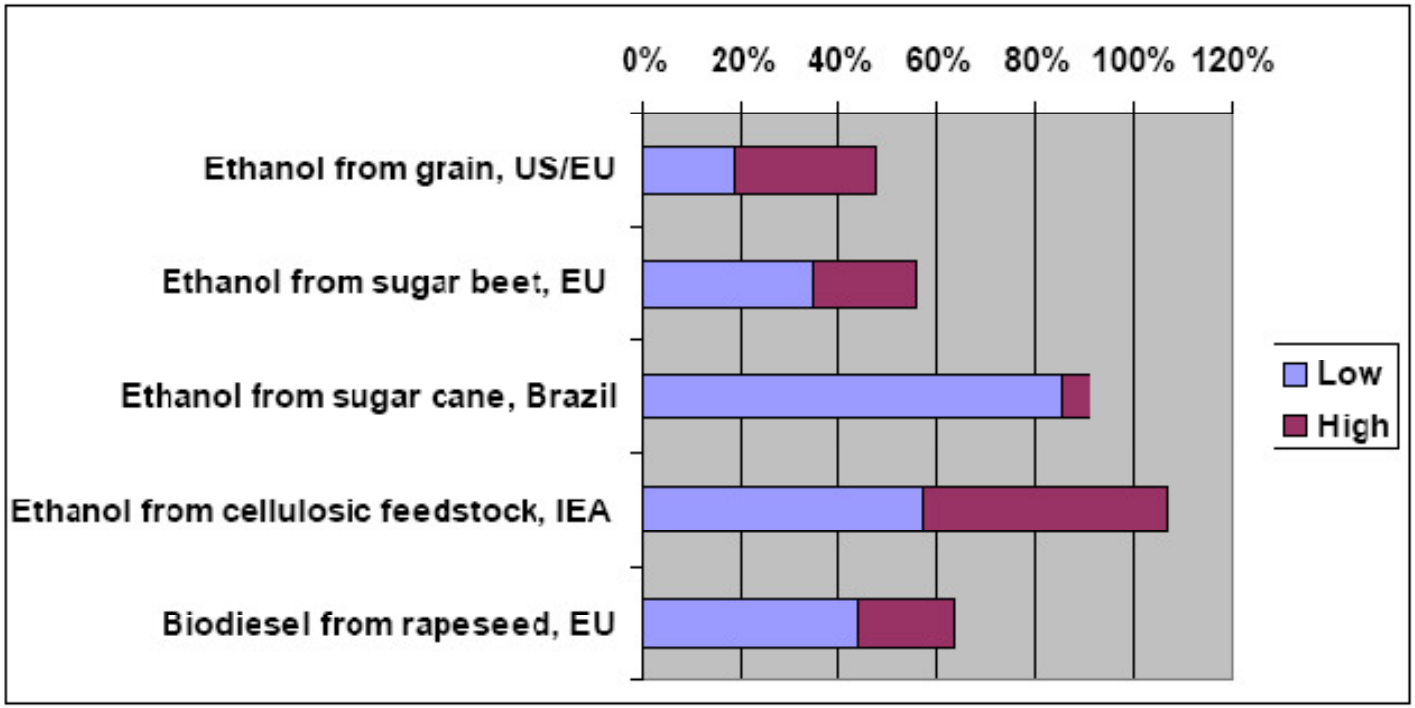


BIOFUELS FOR TRANSPORT

An International Perspective

GHG Reductions Significant, but Vary by Feedstock and Technology

Reductions in well-to-wheel CO2-equivalent GHG emissions per km, from biofuels, compared to gasoline (for ethanol) and diesel fuel (for biodiesel)



Source: IEA estimates based on a review of recent studies

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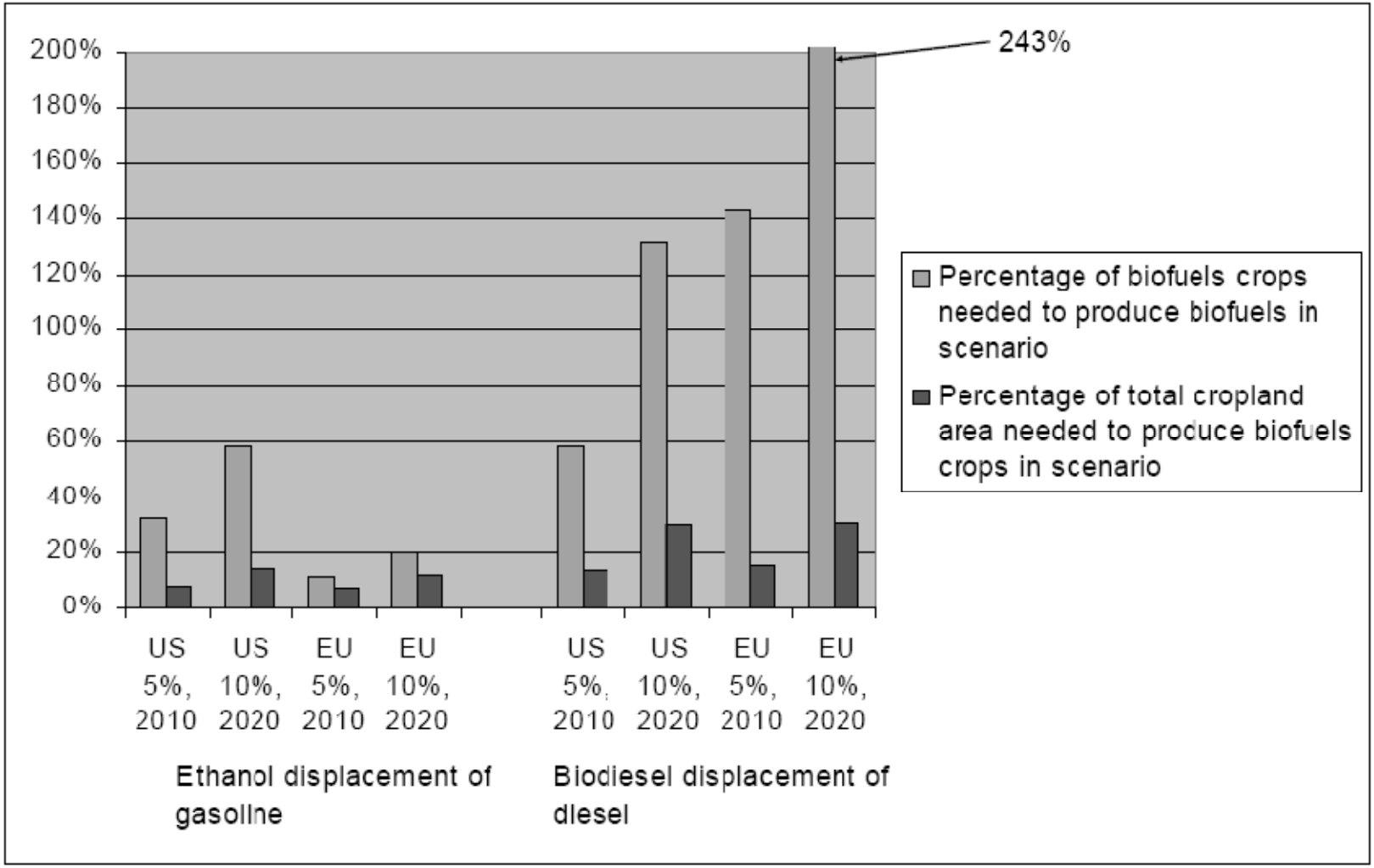
Figure 6.1 Estimated Required Crops and Cropland Needed to Produce Biofuels under 2010/2020 Scenarios



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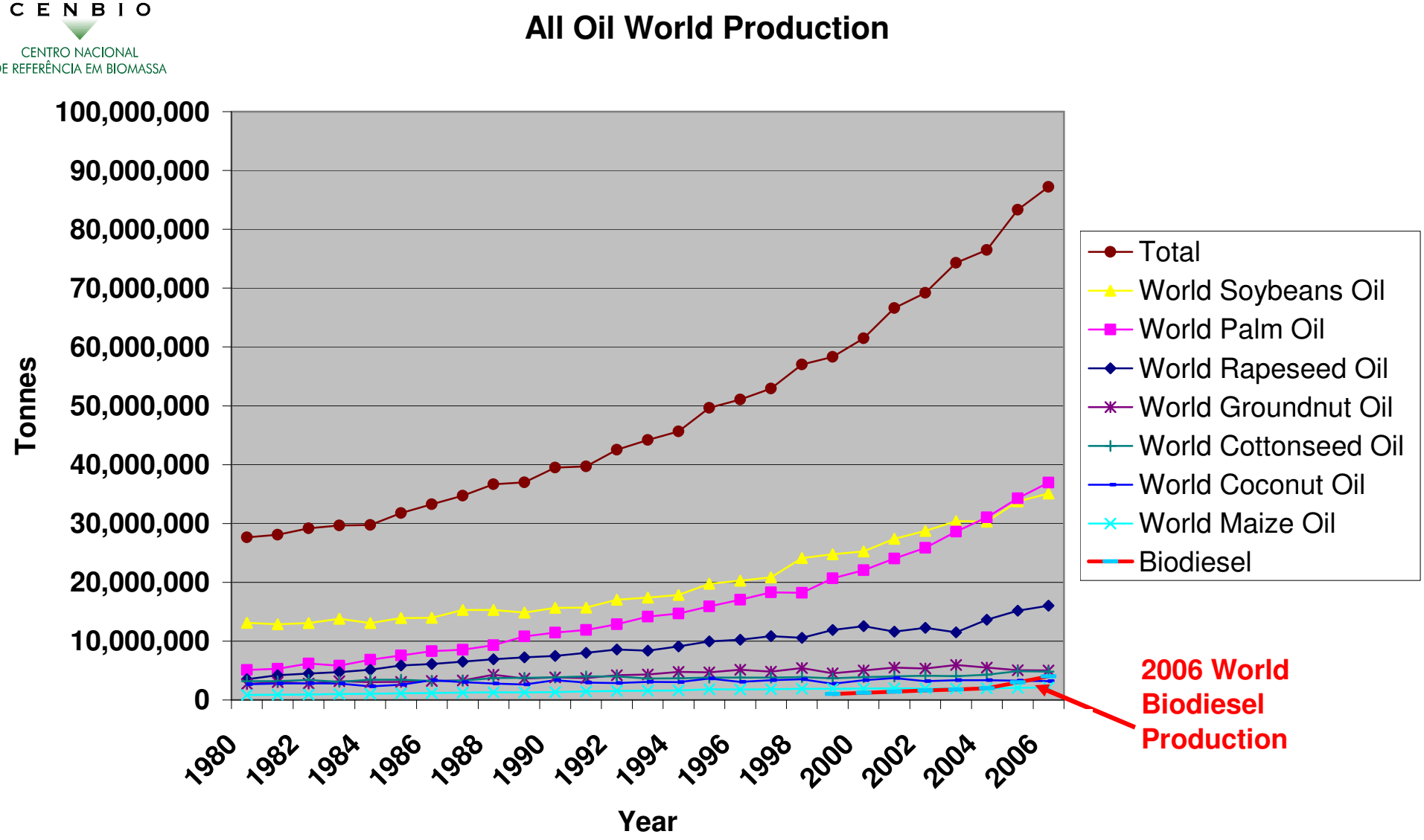

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Advantages with the use of Ethanol in diesel type engines

- Ethanol is renewable, clean and biodegradable;
- Reduction on local air polution: 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

Thank you
Obrigado!!!

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