RESEARCH ROUND TABLE

BIOFUELS: LINKING SUPPORT TO PERFORMANCE

THE PERFORMANCE OF BRAZILIAN BIOFUELS: AN ECONOMIC, ENVIRONMENTAL AND SOCIAL ANALYSIS

Edmar F. de ALMEIDA

Institute of Economics - IE

Federal University of Rio de Janeiro – UFRJ

PARIS, JUNE 2007

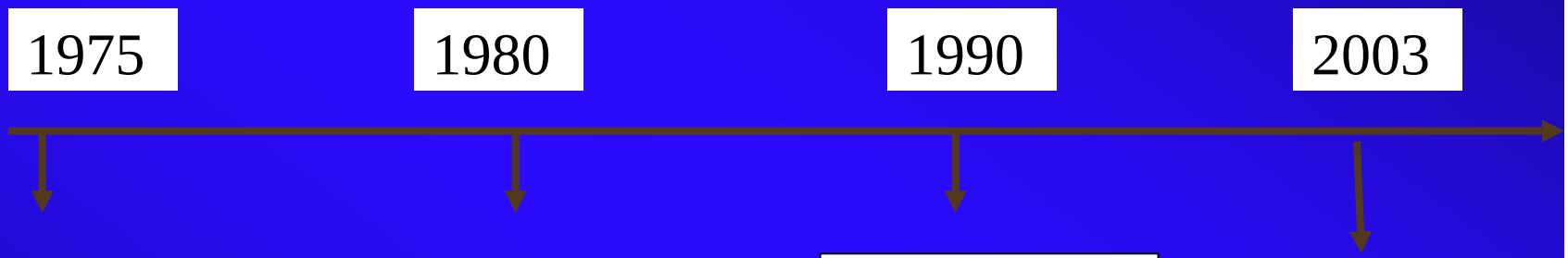
OUTLINE OF THE PRESENTATION

- Ethanol
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Social performance;
  - ➔Energy security performance;
  - ➔Brazil as a world-class ethanol exporter.
- Biodiesel
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Brazil as a world-class biodiesel exporter

OUTLINE

- Ethanol
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Social performance;
  - ➔Energy security performance;
  - ➔Brazil as a world-class ethanol exporter.
- Biodiesel Performance
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Brazil as a world-class biodiesel exporter

BRAZILIAN ETHANOL TIMELINE



Program begins: Increase of the blending to 20%

Blending + Dedicated cars (100% Hydrated ethanol use)

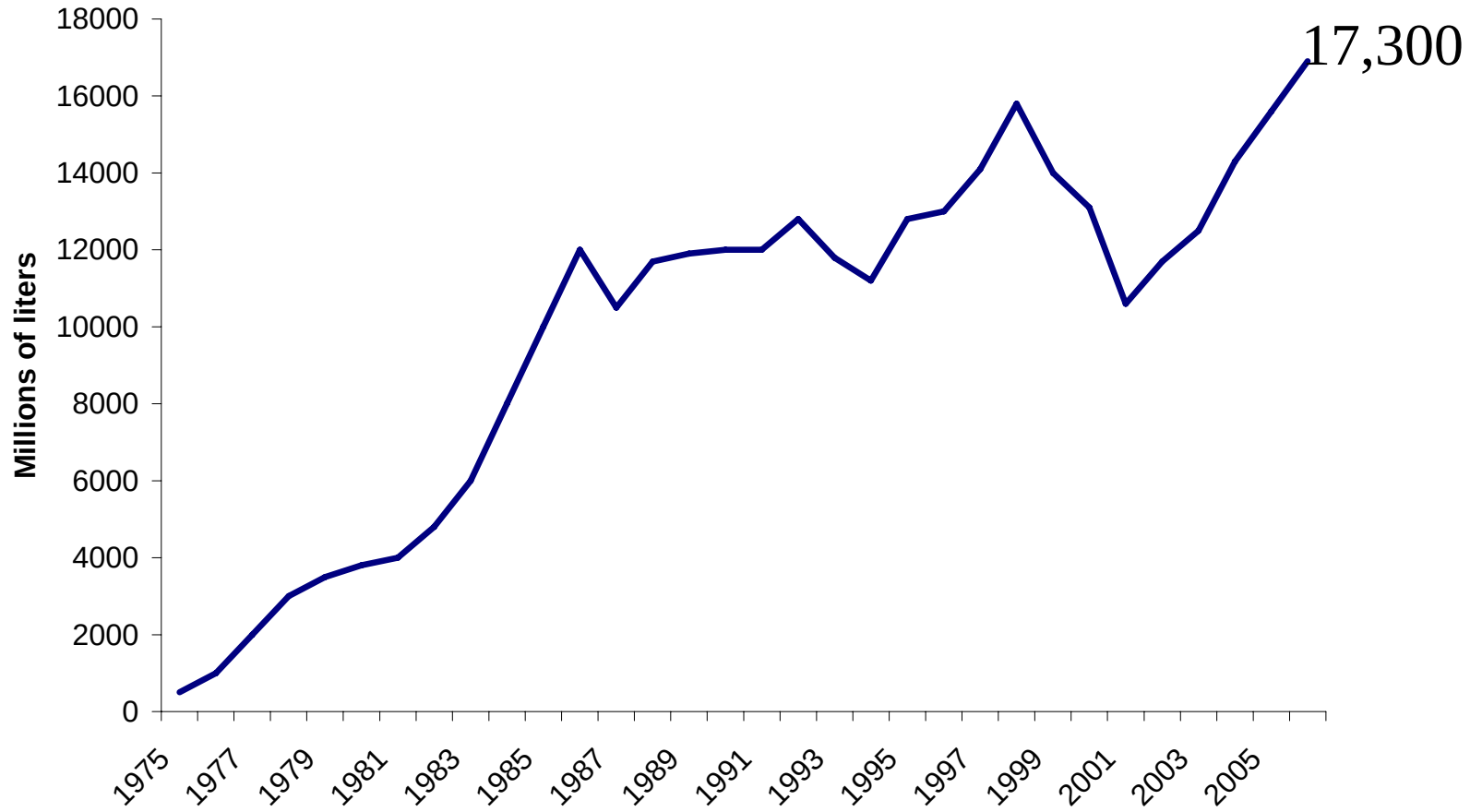
Blending – up to 25% - End of government support to dedicated cars

Blending + FFV's

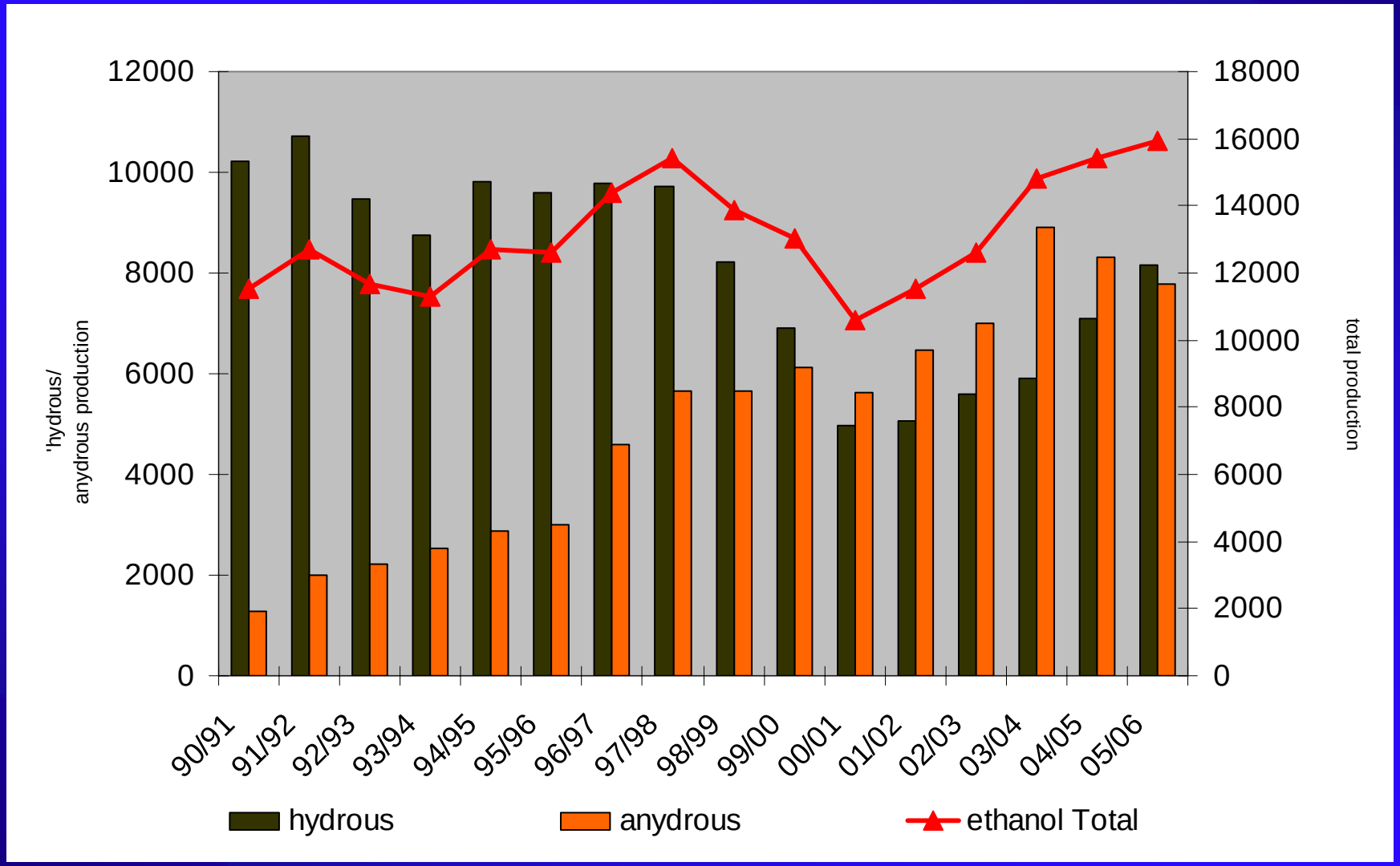
ETHANOL CURRENT STATUS

- Ethanol Production: 17.7 billion Liters in 2006
- Sugarcane
  - ➔ 6.5 millions hectares and 450 million tones
  - ➔ half of sugarcane is converted to ethanol.
  - ➔ 370 sugar and ethanol mills
- 17% of all vehicle fuel supply in Brazil
- Ethanol rush since 2005!
  - ➔ Oil price increase
  - ➔ FFVs in Brazil
  - ➔ Development of the international market

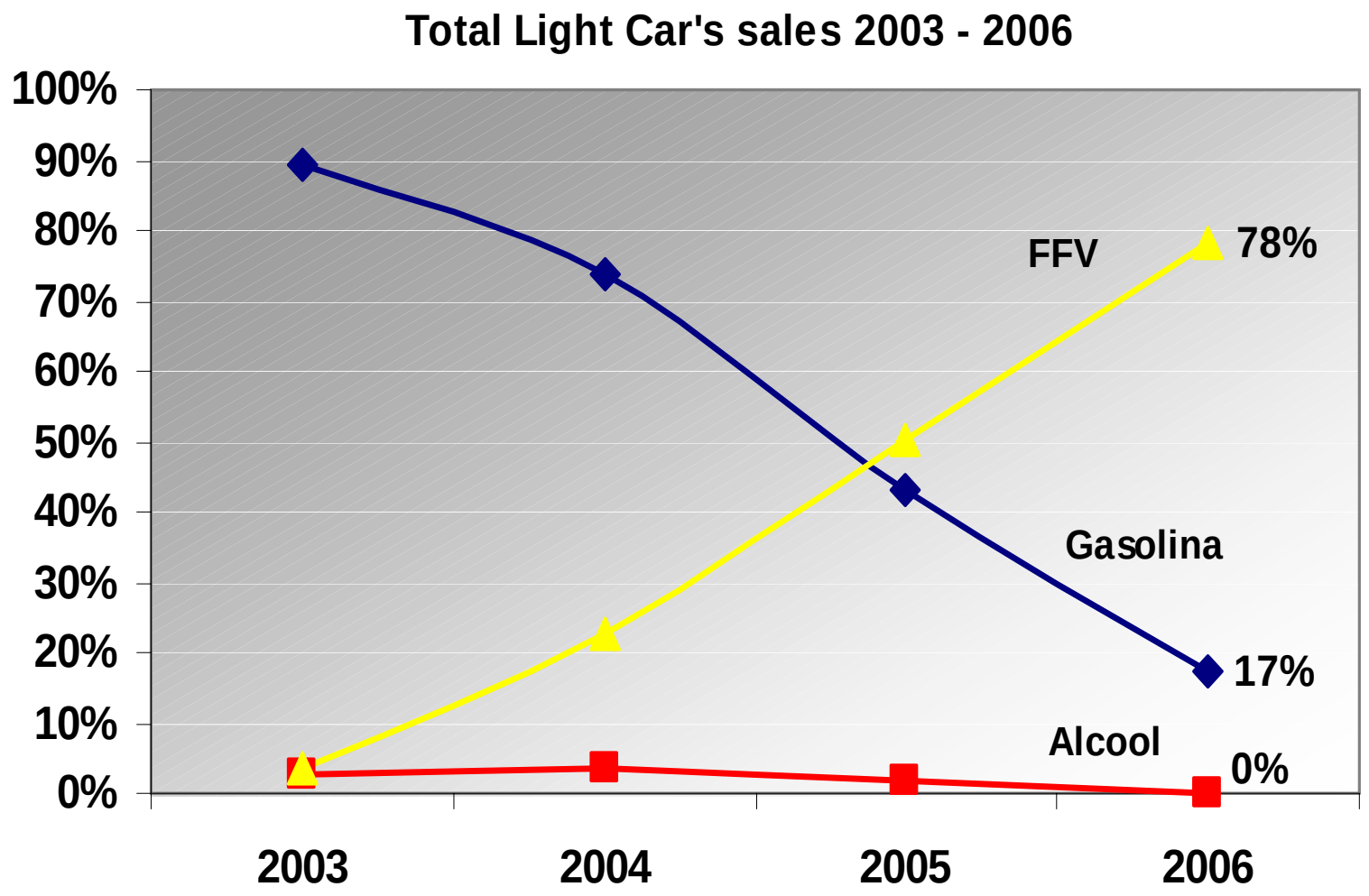
ETHANOL: EVOLUTION OF PRODUCTION - 1



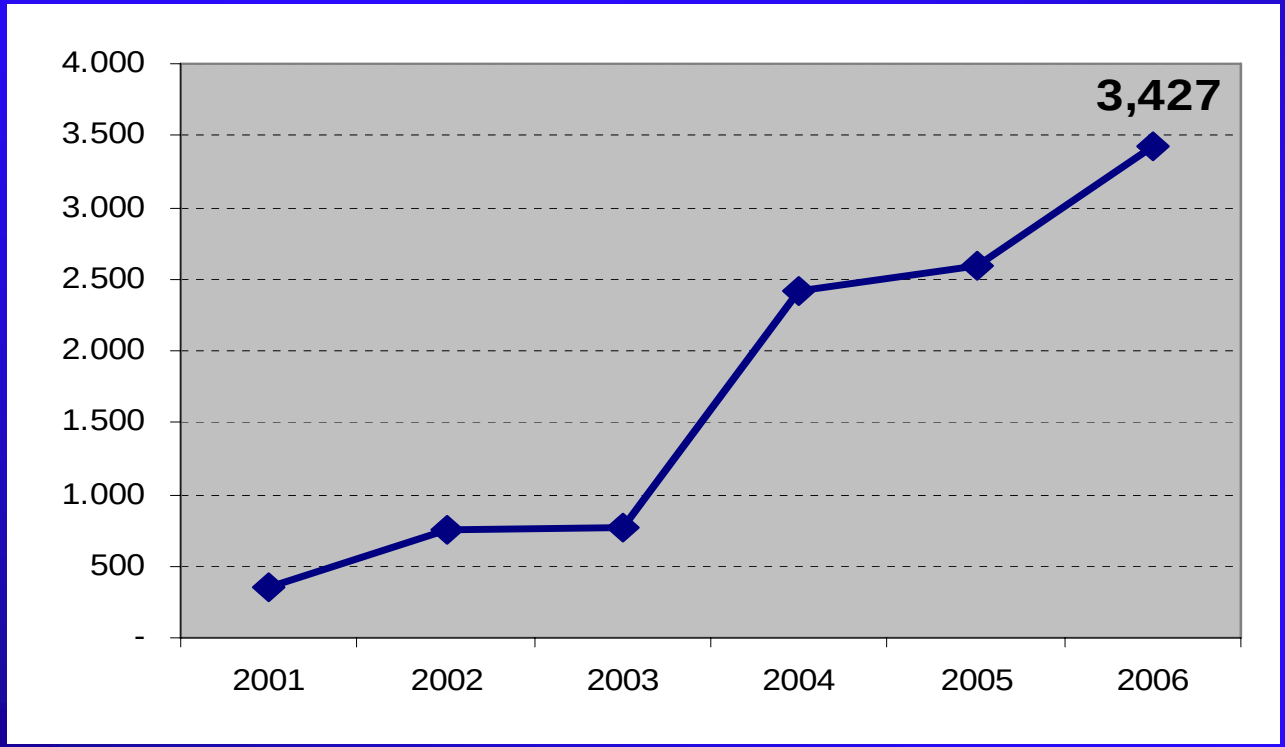
ETHANOL: EVOLUTION OF PRODUCTION - 2



LIGHT VEHICLE SALES BY TYPE



ETHANOL EXPORTS (million liters)



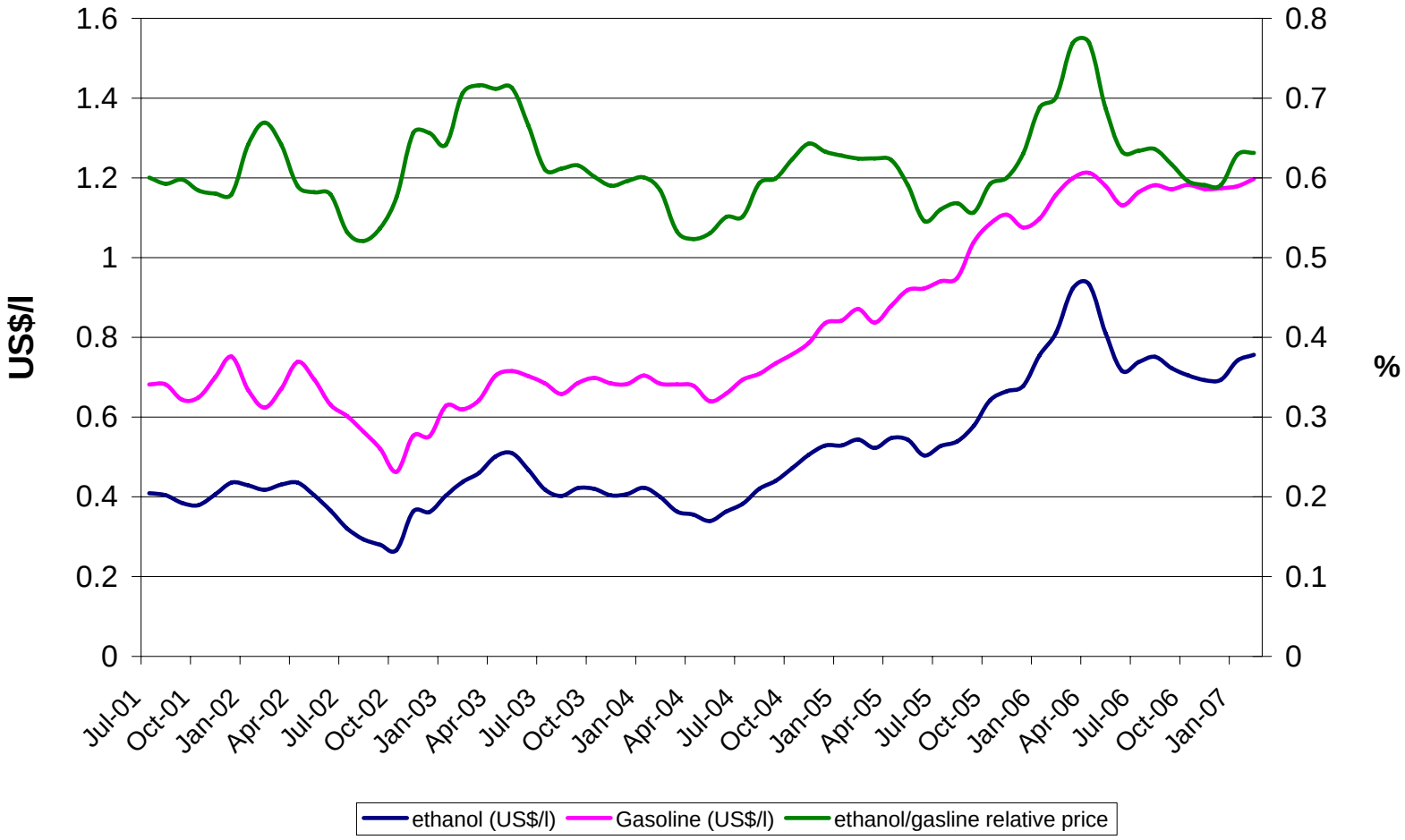
Main Importers

- **USA = 52%**
- **CBI = 14%**
- Netherlands = 10%
- Sweden = 6%
- Japan = 7%
- South Korea = 3%
- Others = 9%

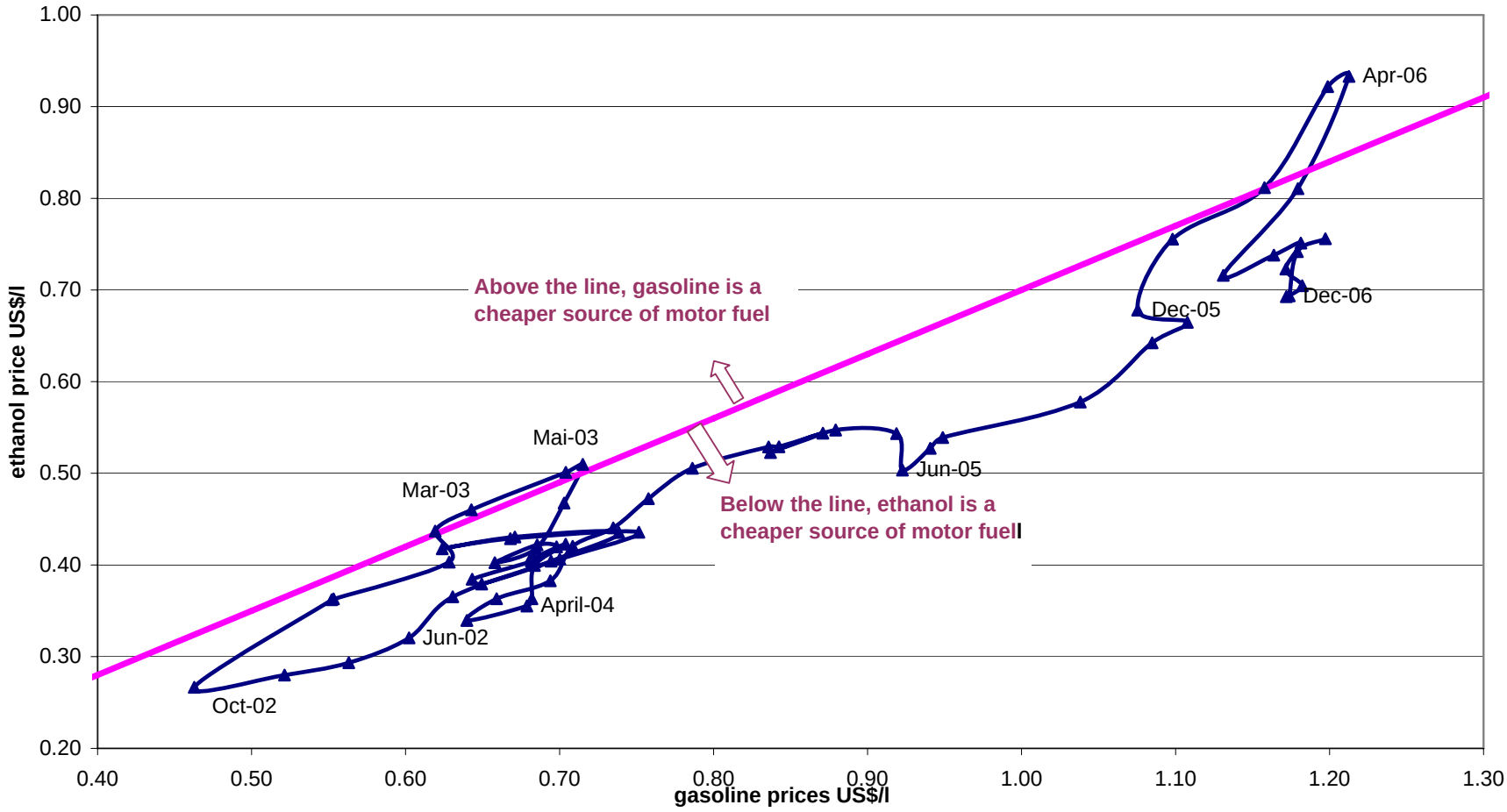
ETHANOL COMPETITIVENES AS COMPARED TO GASOLINE - 1

- Until 1997: ethanol price was fixed at 60% of the gasoline price
- 2002 – Total price liberalization
  - ➔ Relative price varies according to market situation
  - ➔ Ethanol taxes and prices vary in different state
- Ethanol pump prices have been competitive compared to gasoline price (less than 70%)
- This competitiveness is explained by differences in taxation

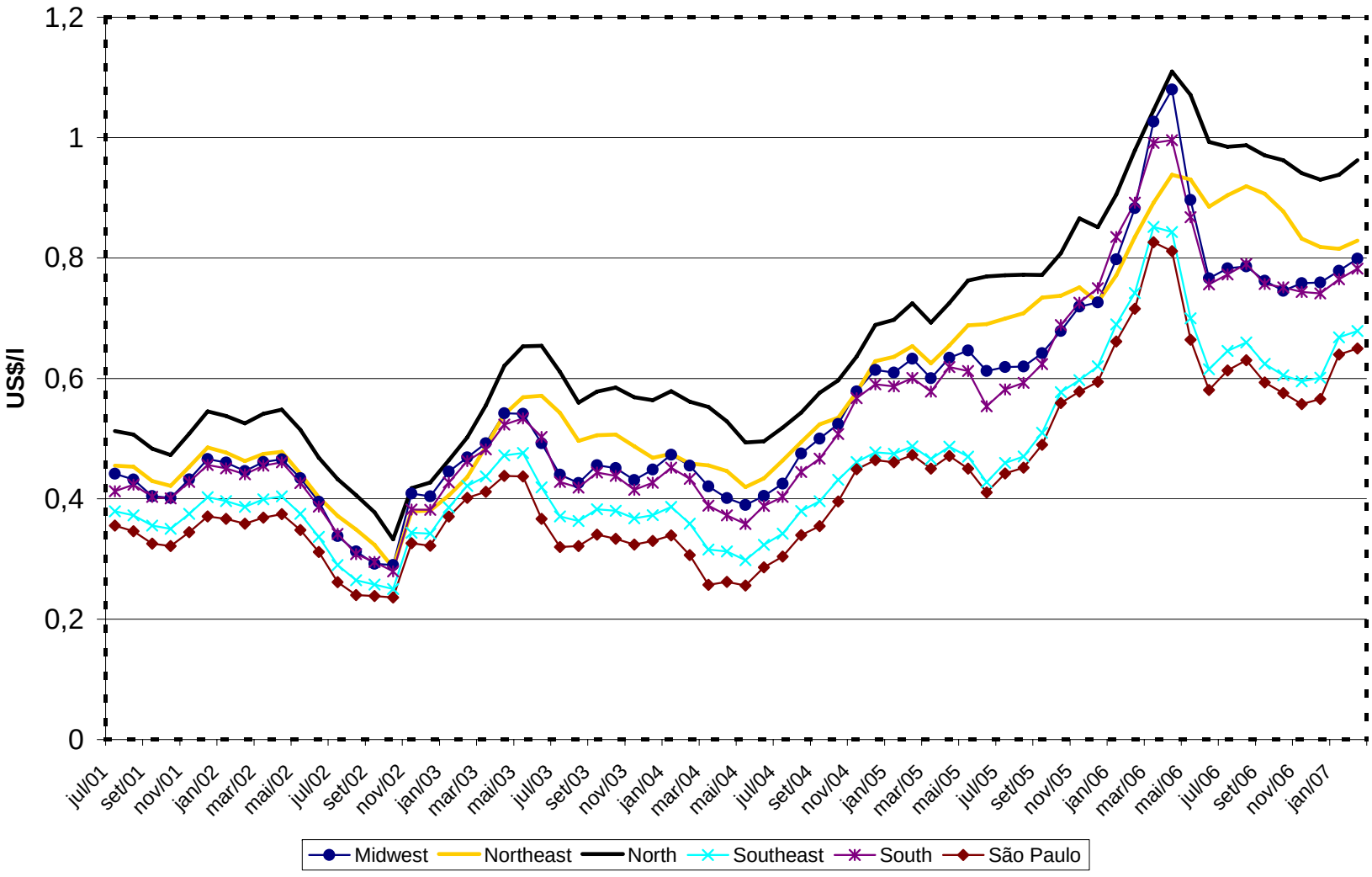
ETHANOL COMPETITIVENES AS COMPARED TO GASOLINE - 2



ETHANOL COMPETITIVENES AS COMPARED TO GASOLINE - 3



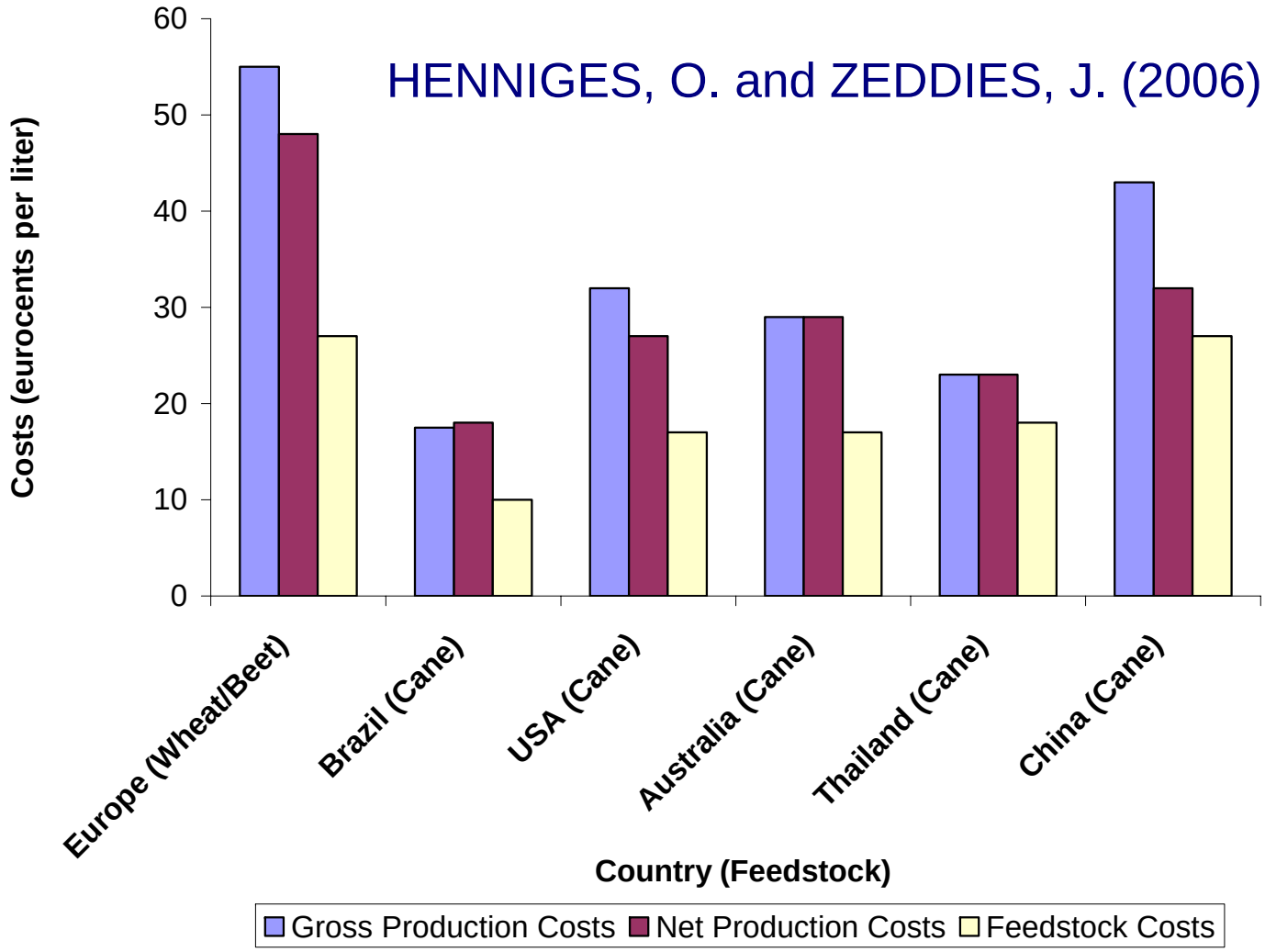
EVOLUTION OF ETHANOL PRICES IN DIFFERENT REGIONS/STATES



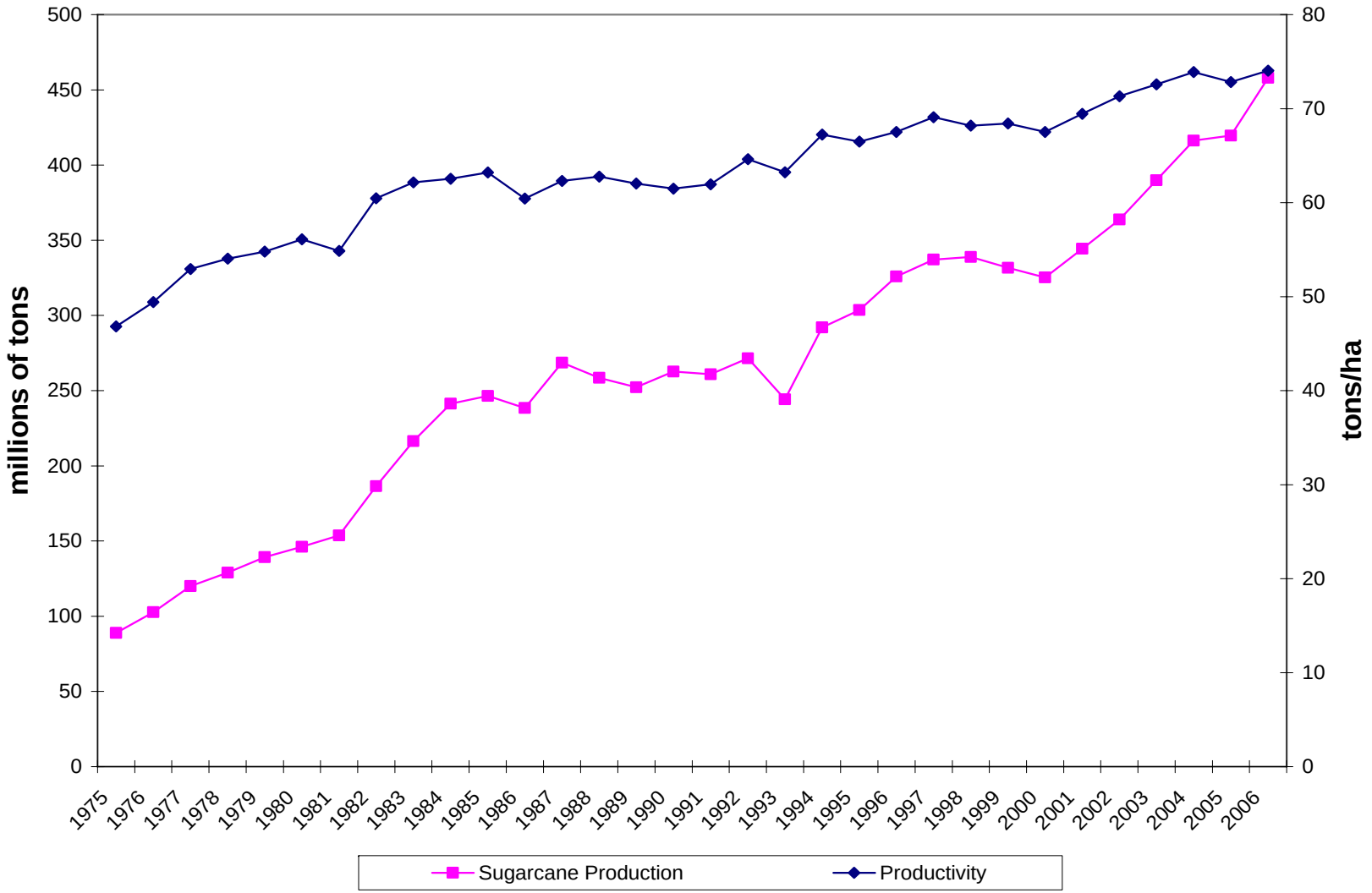
PRODUCTION COSTS

- Most of estimates of production cost does not consider sugarcane opportunity cost
  - ➔ US$ 0,23 /l ~US$ 0,29/ l
- We estimated the production cost for new ethanol projects, including a fair remuneration for the capital, and sugarcane opportunity cost
  - ➔ Long run marginal cost: US$ 0,37 per liter
- Current ethanol producer prices ~ US$ 0.40 per liter. ➔ ethanol prices are above marginal expansion cost
- Brazilian competitiveness is sustained by the feedstock production cost

ETHANOL PRODUCTION COSTS WITHOUT SUBSIDIES



EVOLUTION OF SUGARCANE PRODUCTION AND PRODUCTIVITY

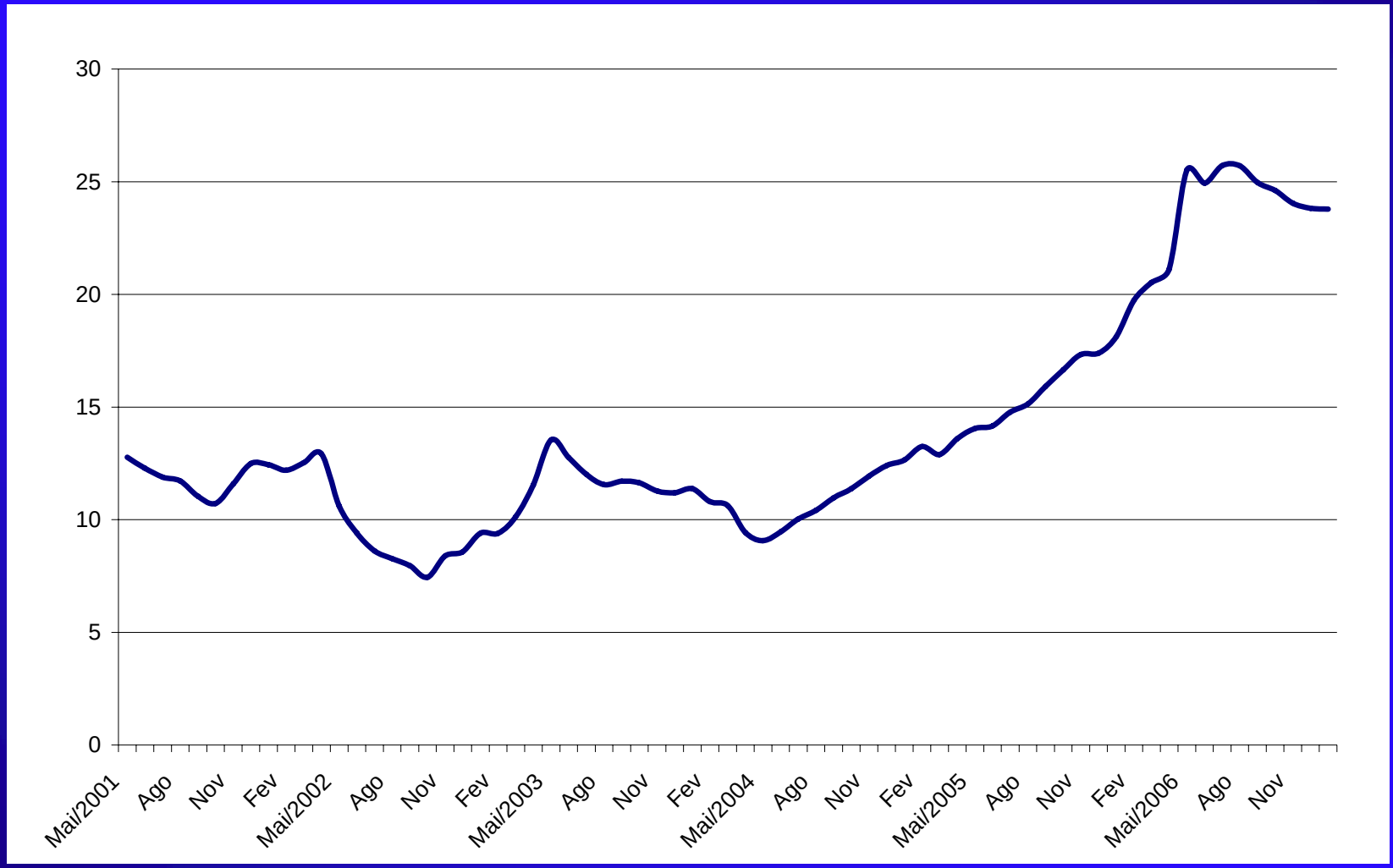


EVOLUTION OF ETHANOL PRICE

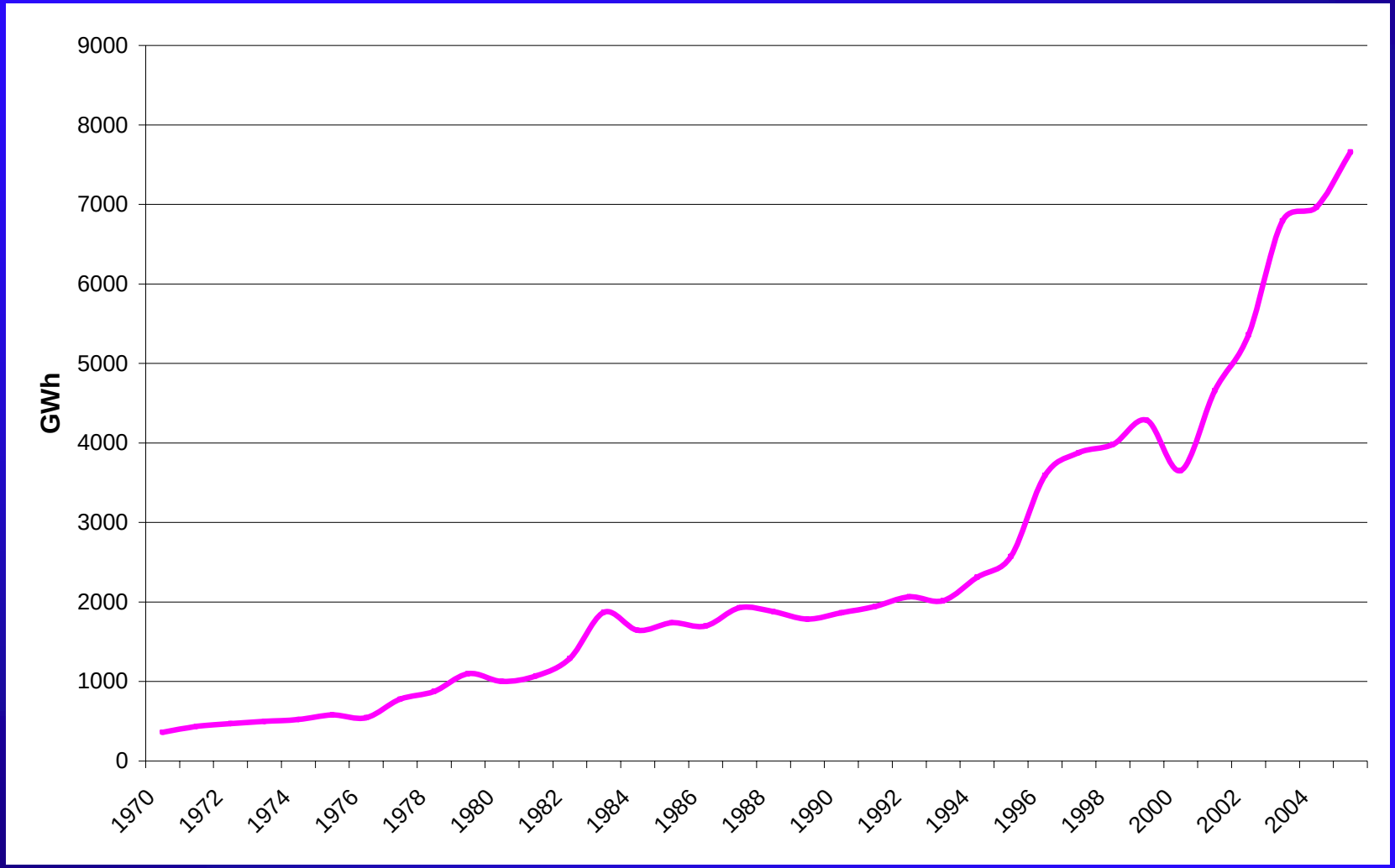
PRODUCTION COSTS

Sugarcane productivity	71.5 t/ha
Sugarcane consumption	2,000,000 ton/ year
Harvesting days	167
Ethanol productivity	85 liter per ton
Ethanol production	170,170,000 liters per year
Surplus power produced	40 kWh/ton of sugarcane
Investment cost in the mill	US$ 97 millions
Investment cost for sugarcane production	US$ 36 millions
O&M Costs	US$ 0.07
Sugarcane Costs	US$ 0.17
Capital costs	US$ 0.13
Total costs	US$ 0.37

EVOLUTION OF SUGARCANE PRICE – US$/TON



ELECTRICITY GENERATION USING BAGASSE AS FUEL IN BRAZIL



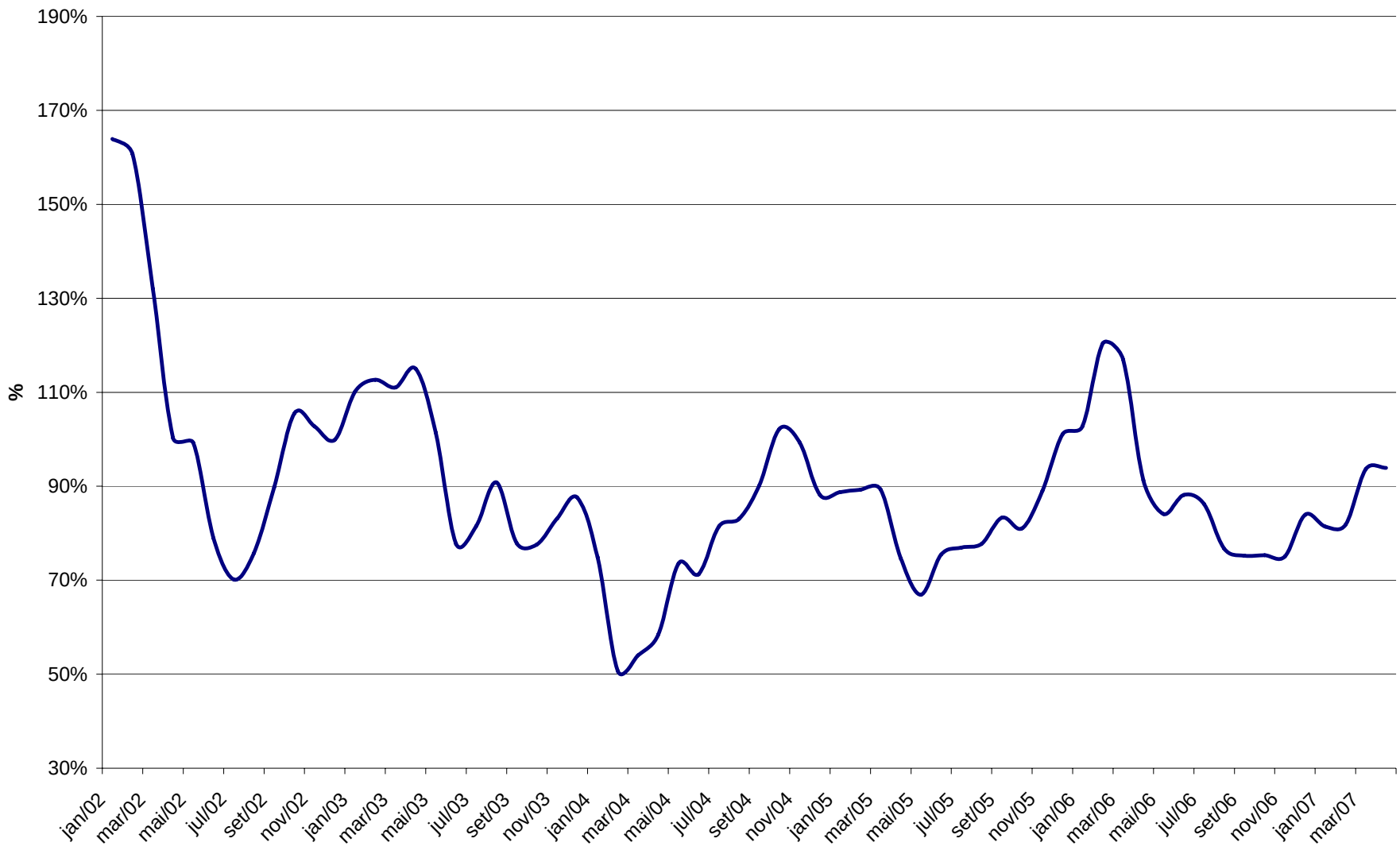
SUBSIDIES IN ETHANOL PRODUCTION

- Tax exemptions to ethanol:
  - ➔ Federal Taxes
    - Ethanol Total Federal Taxes = US$ 0,01/l
    - Gasoline Total Federal Taxes = US$ 0,26/l
  - ➔ State Tax:
    - The difference in the VAT charged over gasoline and over ethanol in the different states.
    - In São Paulo
      - VAT Ethanol = 12% compared to gasoline VAT = 25%
- We estimated the amount of overall tax incentives to ethanol at US$ 977 million per year.

EXPECTED PRODUCTIVITY GAINS

	2005	2015	2025
Sugarcane productivity (t/ha)	70	82	96
Pol (%) Sugarcane	14.5	15.9	17.3
Conversion efficiency (%)	83.5	90.0	90.0
Liters per ton of sugarcane	85	100	109
Liters of ethanol per hectare	6,000	8,200	10,400

ETHANOL/GASOLINE PRICES EXCLUDING TAXES



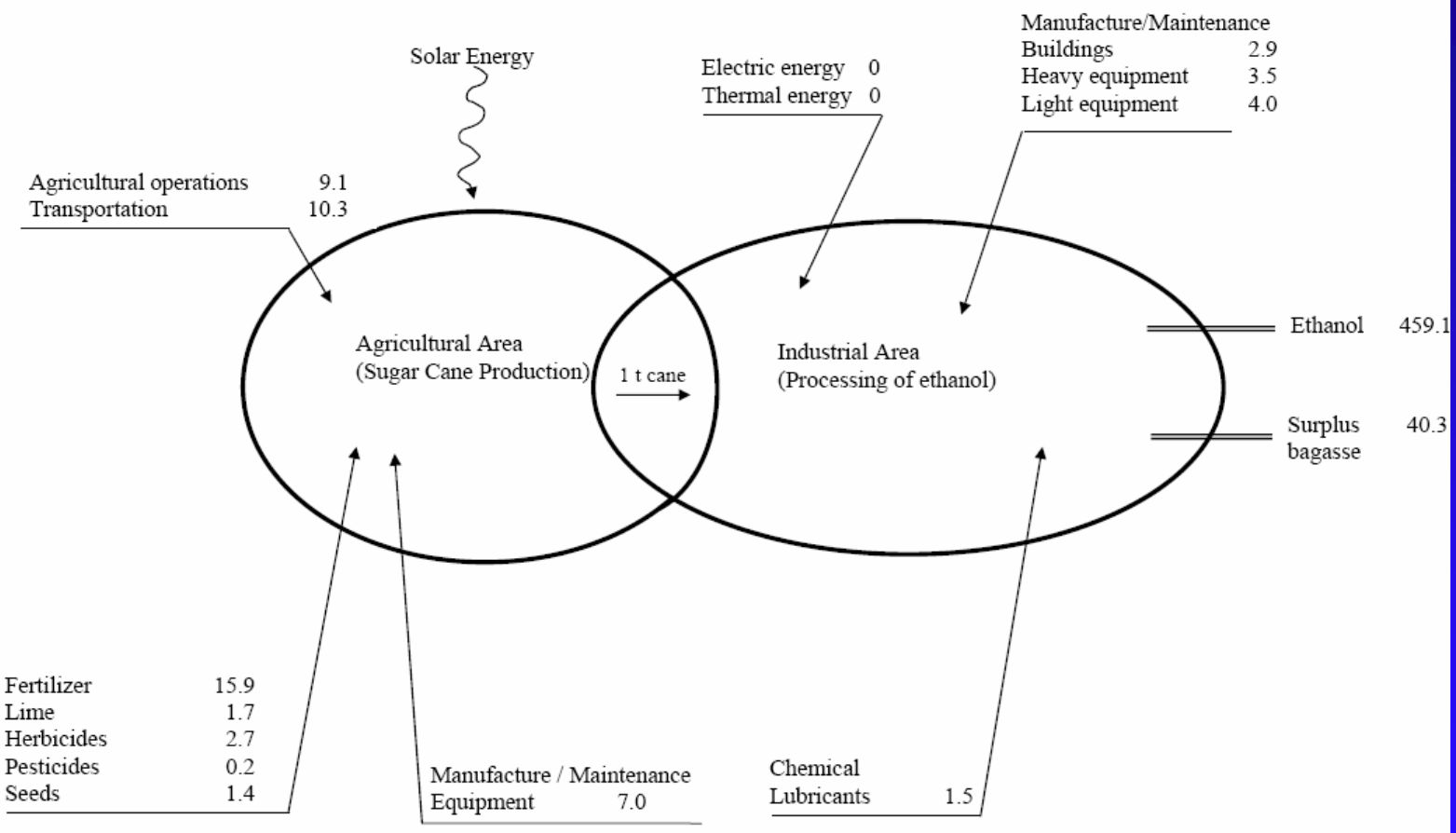
OUTLINE

- Ethanol
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Social performance;
  - ➔Energy security performance;
  - ➔Brazil as a world-class ethanol exporter.
- Biodiesel
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Brazil as a world-class biodiesel exporter

GHG EMISSIONS

- Sugarcane ethanol can reduce more than 80% of the GHG emissions, while ethanol generated from other feedstock can reach 50% in the best case.
  - ➔ Macedo et al. (2004) estimate that for each MJ of fossil fuel used in the process of growing collecting and processing sugar cane 8.3 to 10.2 MJ of ethanol are produced
  - ➔ Ethanol contribution to CO2 reduction: 12 millions tons
- Concerns about indirect impacts on GHG emissions:
  - ➔ About 75% of Brazilian emissions of CO2 are related to deforestation.
  - ➔ Sugarcane expansion and its indirect deforestation impact is still inconclusive.

GHG EMISSIONS – ETHANOL'S ENERGY BALANCE



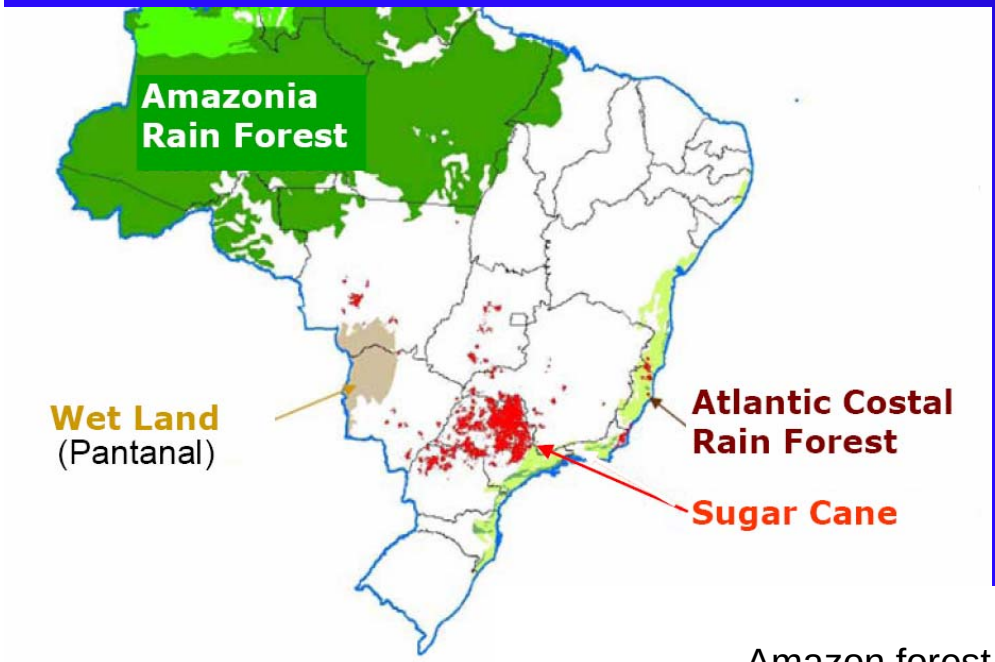
(Renewable energy) / (Fossil Input) = 8.3

Figure 1 - Energy Balance: Scenario 1 (Mcal/TC)

IMPACTS ON DEFORESTATION

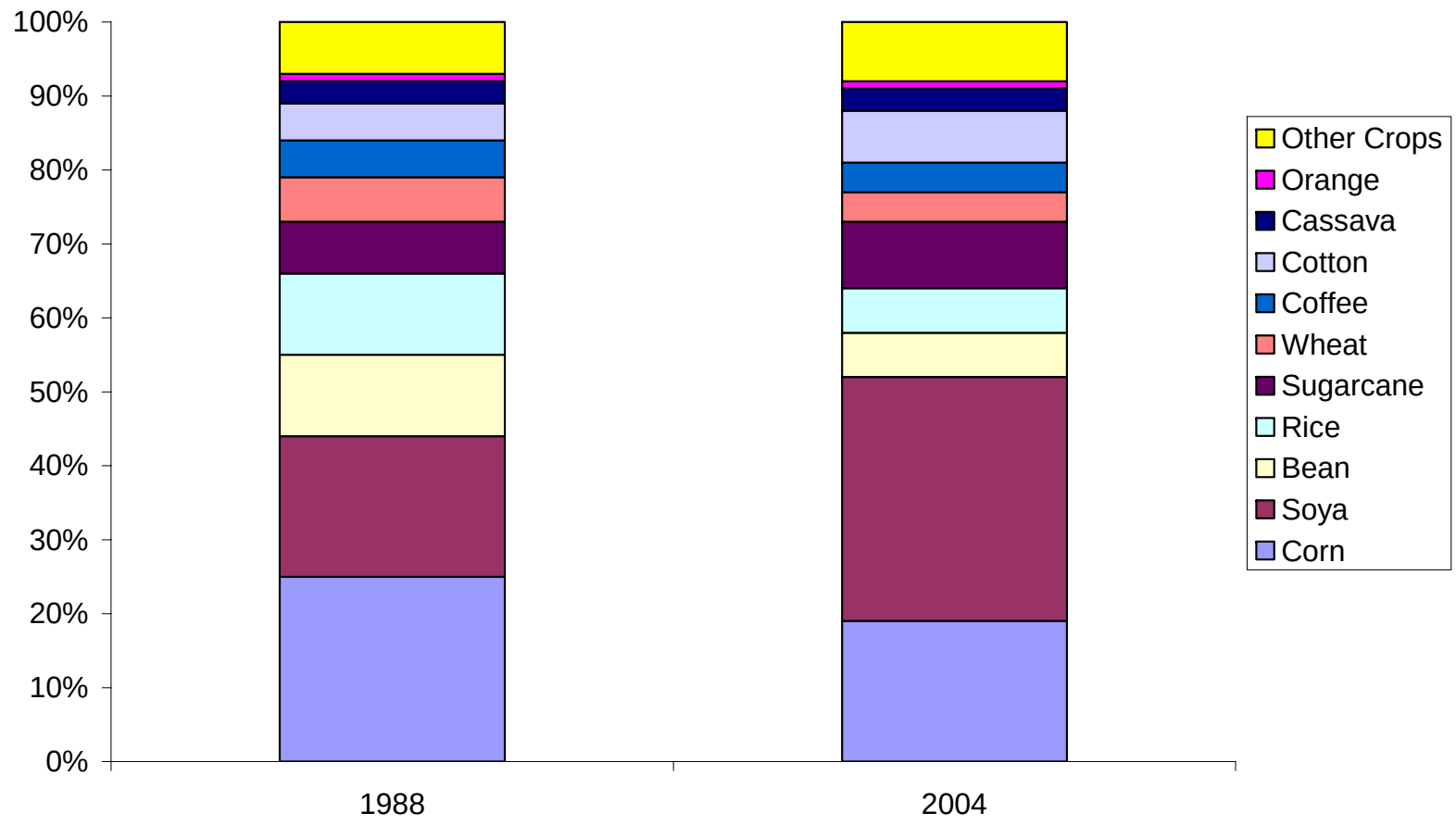
- Deforestation in Brazil
  - ➔ About 3 millions hectares per year (2000-2005)
  - ➔ Cattle raising: 30 million hectares between 1990 and 2005
  - ➔ Soybean: 3 million hectares
  - ➔ Timber exploration
- Direct impacts of sugarcane:
  - ➔ Small since ethanol production area is far from amazon region
  - ➔ Ethanol production needs distribution logistics
- Indirect impact:
  - ➔ Sugarcane is expanding to the Midwest replacing cattle breeding
  - ➔ Cattle breeding expands in forest zone
  - ➔ Cattle breeding expansion is related to other factors: land availability and land costs
  - ➔ Research on ethanol X cattle breeding x deforestation are not conclusive so far
  - ➔ 30% of pasture are degraded → sugarcane can recover these areas and result in positive GHG balance

IMPACTS ON DEFORESTATION



	ha	% of total
Amazon forest and protected areas	405	47%
Farmland	275	31%
- pasture	210	24%
- agriculture	65	8%
Cities, towns, lakes	20	2%
Land available for agriculture	90	10%
Land available for sugarcane	22	3%
Other uses	60	7%
total	851	100%

EVOLUTION OF CROPLAND BY TYPE OF CROP



LOCAL IMPACTS: WATER MANAGEMENT:

- Water consumption has been reduced from 5.6 m3/t cane in the 1990s to 1.83 m3/t in 2005 at São Paulo´s mills.
  - ➔ New technologies will allow a further reduction to less than 1 m3/t cane water collection and (close to) zero effluent release rates, through reuse of water.
  - ➔ Cost of non treated water collected from major rivers = R$0.01 / m3.
  - ➔ ➔ total water cost would be US$ 4.5 millions per year. The water cost for a typical mill : US$ 40,000 per year.
  - ➔ Tariff for polluted water discharges is R$0.07 and R$0.1 per kilo. It's cheaper to treat the polluted water before discharge.

IMPACTS OF BURNING BEFORE HARVESTING

Emission	Grams per kg of dry straw	Kg/ton of sugarcane	Thousand tons per year
CH4	0.41	0.05	15
CO	25.48	3.19	917,280
Nox	1.4	0.18	50,400
SO2	0.62	0.08	22,320
Particulates	5.60	0.7	201,600
Particulates 10	5.4	0.69	194,400
Particulates 2,5	5	0.63	180,000
N2O	0.12	0.015	4,320

Legislation regarding Mechanization in São Paulo:

- Flat areas, 100% by 2021.
- Non-flat areas, 100% mechanization by 2031.

ENVIRONMENTAL IMPACTS

- Environmental performance in Brazil is far from being a question of laws and business rules
- Crucial question: Capacity of law enforcement
  - ➔ Brazil has a very modern environmental regulatory framework
  - ➔ Government has a weak enforcement capacity
  - ➔ Enforcement capacity is asymmetry
    - Relatively strong for sectors organized and composed by large companies
    - Weak for small businesses (farmers, for instance)

OUTLINE

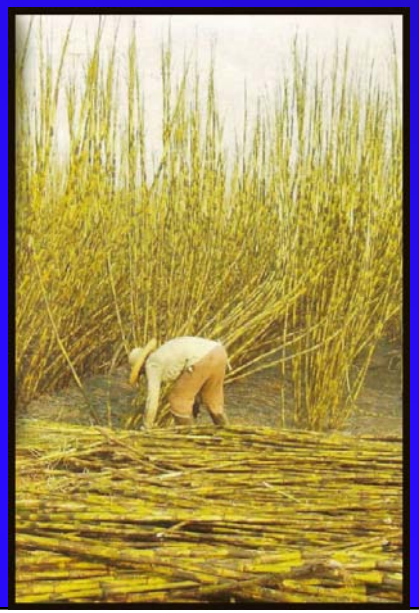
- Ethanol
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Social performance;
  - ➔Energy security performance;
  - ➔Brazil as a world-class ethanol exporter.
- Biodiesel Performance
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Brazil as a world-class biodiesel exporter

SOCIAL IMPACTS - 1

- The social impacts are one of the main reasons behind government support to ethanol industry
- Sugar and ethanol production represents about 3% of GDP
- The ratio “jobs per energy unit” is estimated to be 100 times greater than in oil production
- Jobs created:
  - → direct jobs → 700 thousand
  - → indirect jobs→ 200 thousand
- Low quality jobsis still in Brazil

SOCIAL IMPACTS - 2

- Jobs quality:
  - ➔ Seasonal job employing migrant workers
  - ➔ involve insalubrious activities (manual harvesting)
  - ➔ Salaries depend on minimal productivity per day
- Mechanization:
  - ➔ Unemployment
  - ➔ But jobs tend to be of better quality
  - ➔ Production expansion could partially compensate unemployment related to mechanization



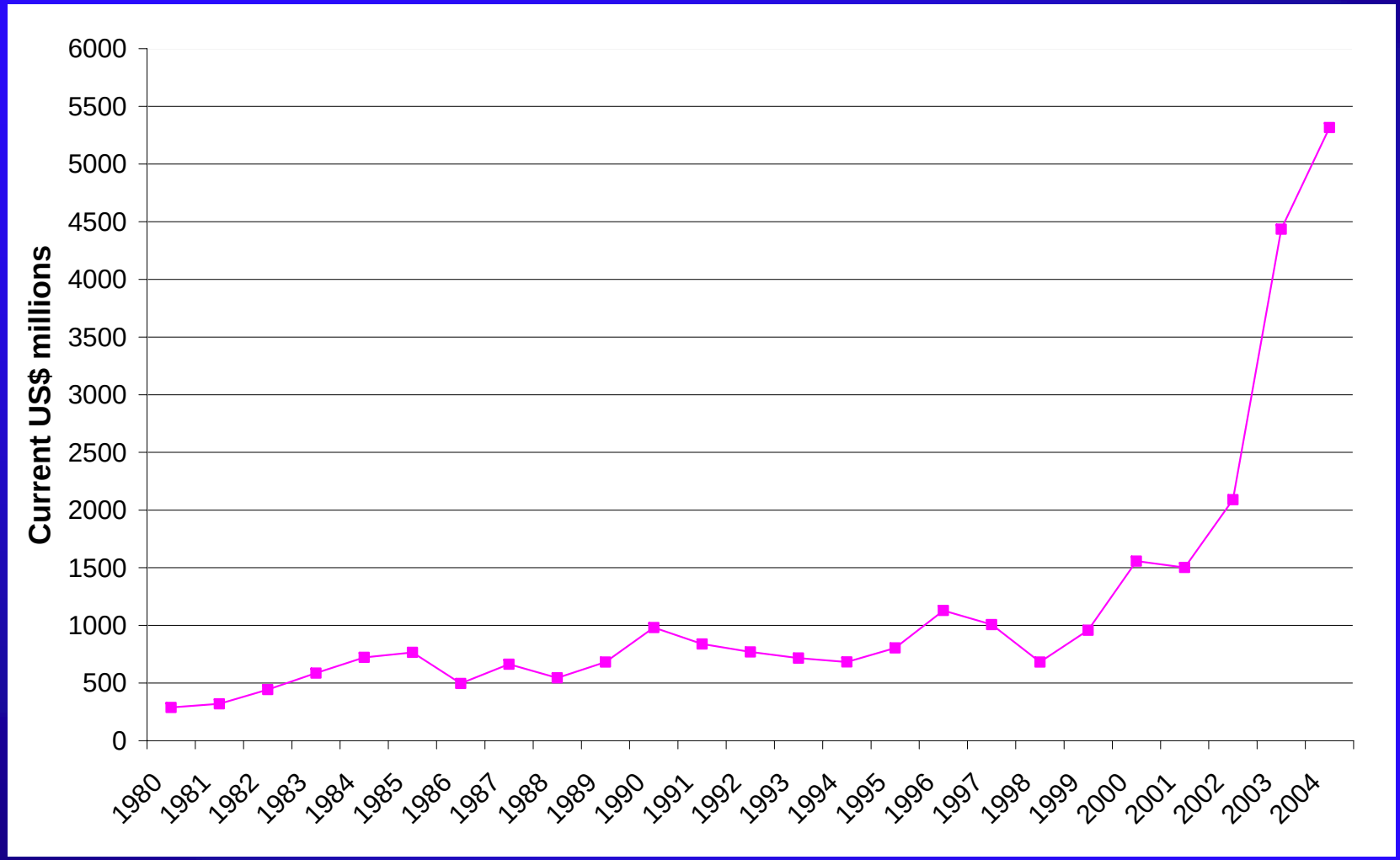
OUTLINE

- Ethanol
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Social performance;
  - ➔Energy security performance;
  - ➔Brazil as a world-class ethanol exporter.
- Biodiesel Performance
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Brazil as a world-class biodiesel exporter

ENERGY SECURITY

- The Pro-Alcohol: After 1980, ethanol production in Brazil was equivalent to 10% of all oil products consumed.
- The annual value of the avoided imports fluctuated between US$ 500 million and one billion dollars in the 1980s and 1990s.
- Today, macroeconomic restrictions related to oil imports are no so relevant.
  - ➔ In 2006, Brazil reached self-sufficiency in oil production.
  - ➔ Biofuels are seeing as a secure path for guaranteeing long-term energy supply in a context of increasing environmental restrictions.

VALUE OF THE AVOIDED IMPORTS OF OIL AND OIL PRODUCTS DUE TO ETHANOL CONSUMPTION



OUTLINE

- Ethanol
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Social performance;
  - ➔Energy security performance;
  - ➔Brazil as a world-class ethanol exporter
- Biodiesel Performance
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Brazil as a world-class biodiesel exporter

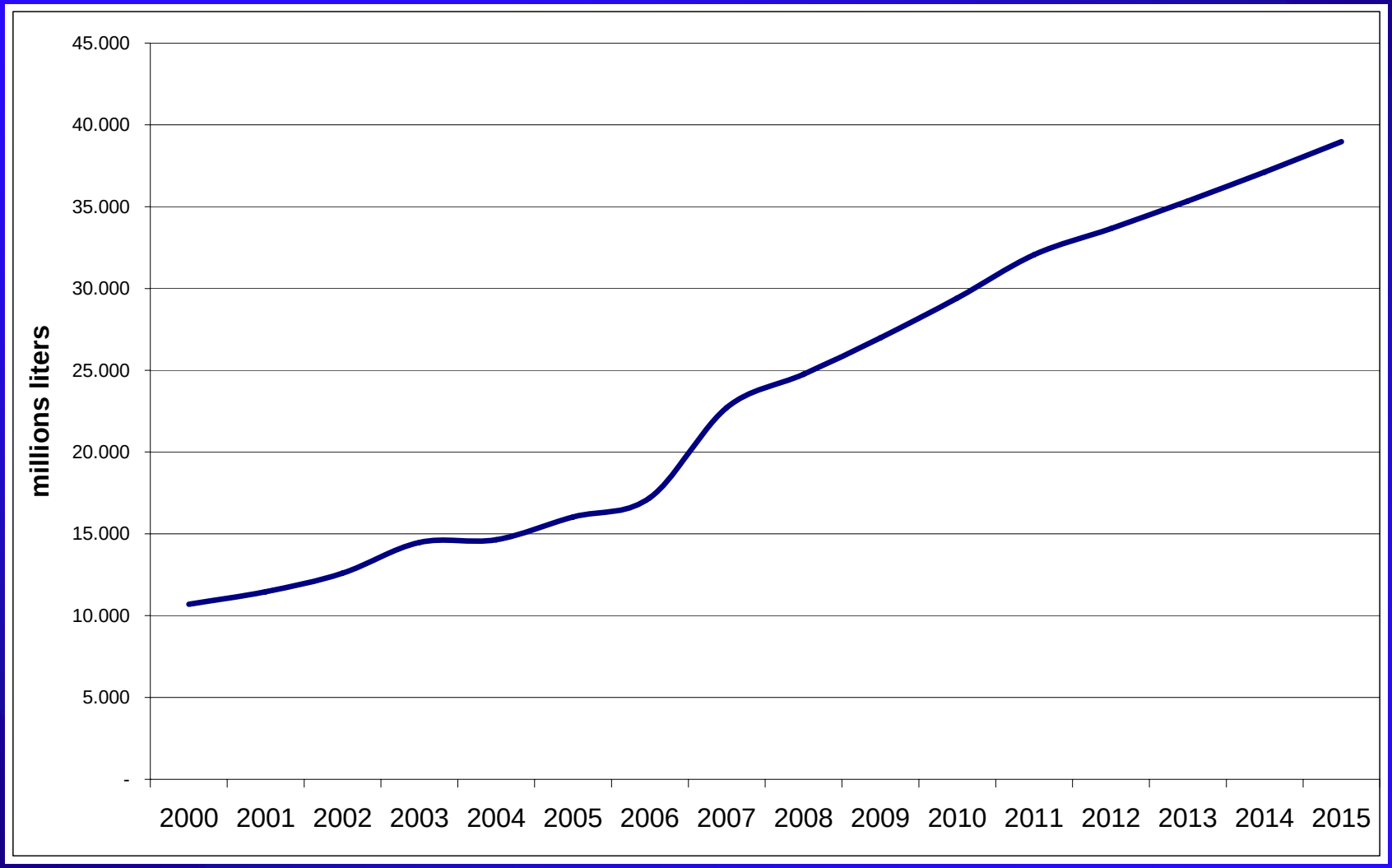
5) Brazil Future Exports

- The role of Brazil in the world ethanol market will depend on:
  - ➔the Brazilian ethanol production;
  - ➔the domestic ethanol demand;
  - ➔the development of an international ethanol market

BRAZILIAN ETHANOL PRODUCTION

- Brazil alone could produce 5% of all gasoline demand by 2025
  - ➔ 1.2 billion tons of sugarcane
  - ➔ 104.5 billion liters of ethanol
  - ➔ 21.5 millions hectares
  - ➔ 5 million direct and indirect jobs
  - ➔ Ethanol export's: US$ 31 billion
- Current ethanol investment rush
  - ➔ Capacity under construction or planned represents 20% of existing capacity
  - ➔ About 25 new mills will come on stream in 2007
  - ➔ About 90 projects have been announced for the period of 2008-2014
  - ➔ New international investment funds dedicated to ethanol

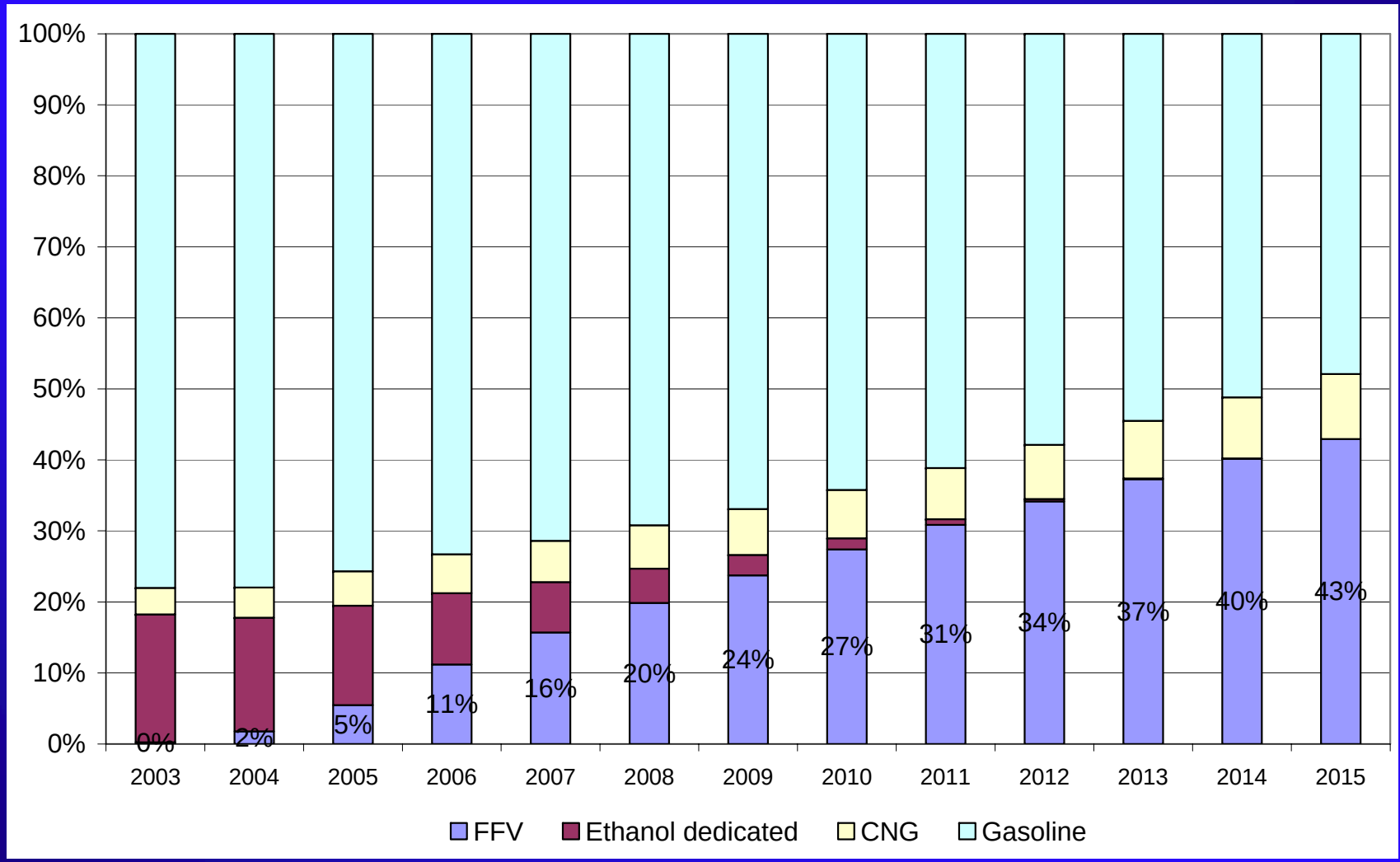
PROJECTIONS OF ETHANOL PRODUCTION



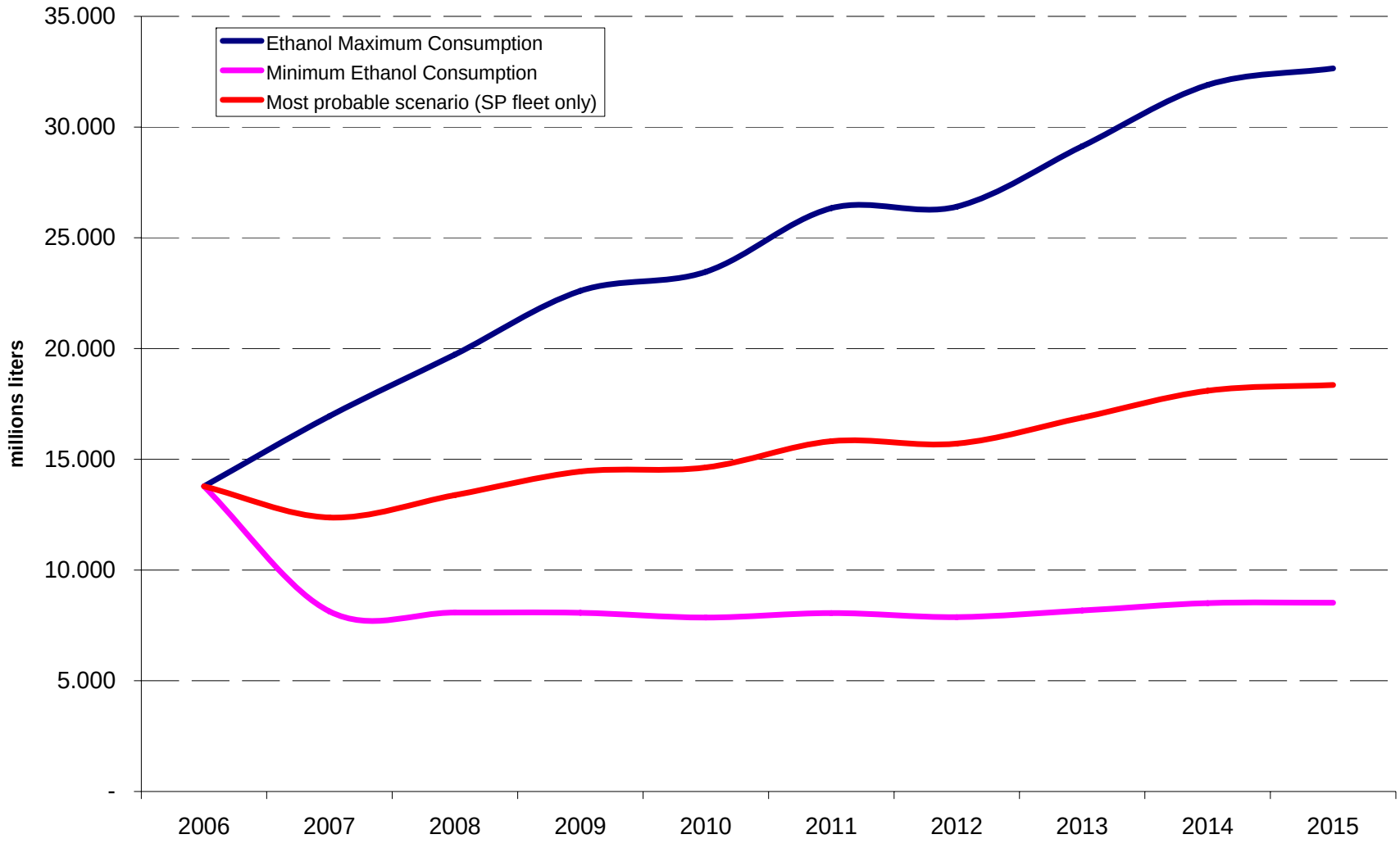
DOMESTIC ETHANOL DEMAND

- Domestic demand will depend basically on the following variables
  - → FFV sales and fleet
  - → Ethanol prices in Brazil
- We projected three scenarios for ethanol consumption:
  - → Scenario 1 → ethanol prices in Brazil would be attractive (less than 70% of gasoline prices)
  - → Scenario 2 → ethanol prices to be unattractive to FFVs and the all FFVs would run on gasoline
  - → Scenario 3 - part of the FFVs fleet will consume ethanol, despite the fact that ethanol prices in the international market tend to be higher than 70% (more likely)

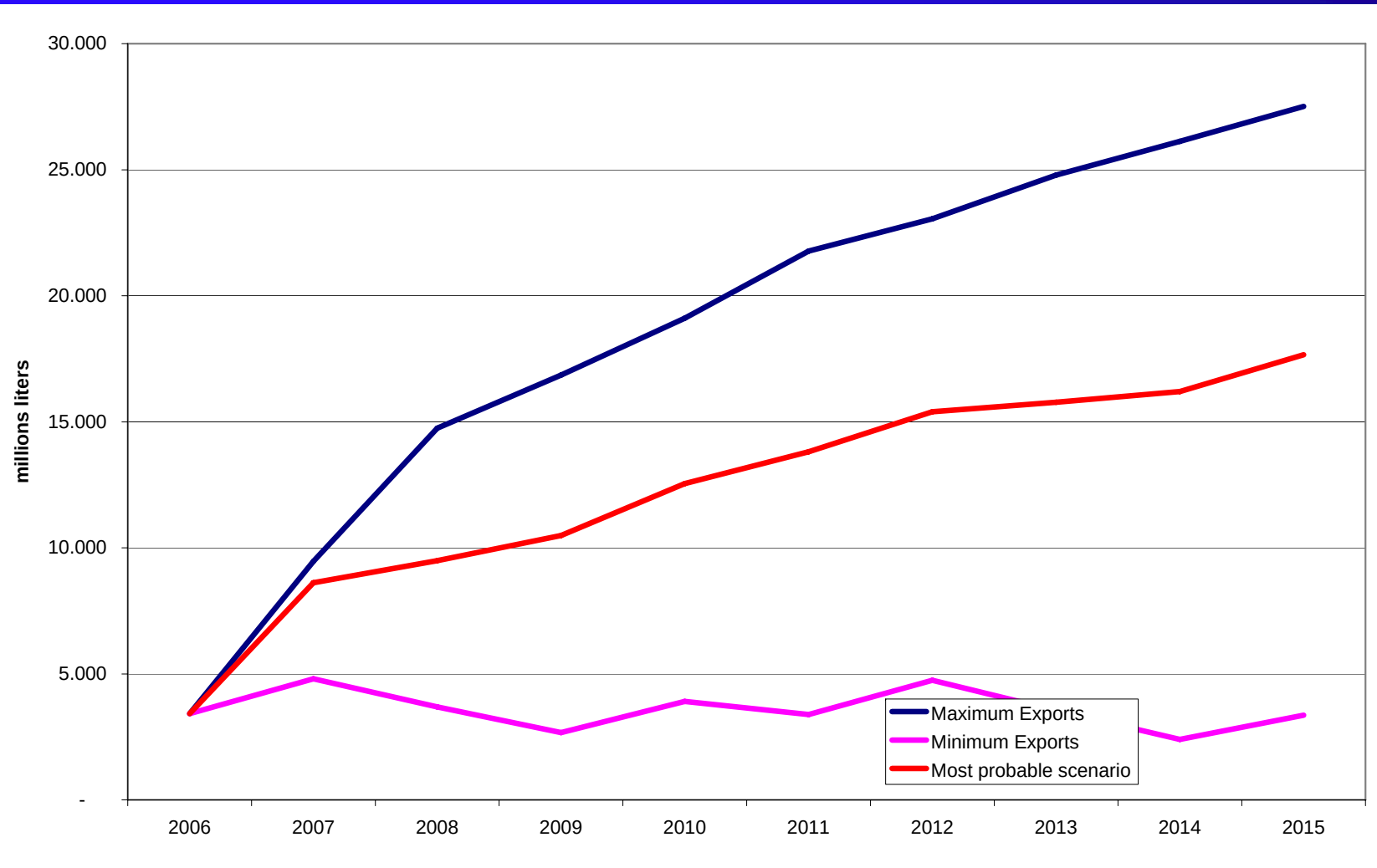
EVOLUTION OF THE COMPOSITION OF LIGHT VEHICLE FLEET IN BRAZIL



PROJECTIONS OF ETHANOL CONSUMPTION



PROJECTIONS OF ETHANOL EXPORTS



DEVELOPMENT OF INTERNATIONAL ETHANOL MARKET

- Obstacles :
  - ➔ i) the high concentration of the export capacity in Brazil raises security of supply issues;
  - ➔ ii) trade barriers and subsidies to domestic production in Europe and the US;
  - ➔ iii) doubts/questioning regarding the environmental impacts Brazilian ethanol.
- A necessary condition: environmental certification process.
- An important research effort is still to be done for subsidizing the market organization and the development of a certification process

OUTLINE

- Ethanol
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Social performance;
  - ➔Energy security performance;
  - ➔Brazil as a world-class ethanol exporter
- Biodiesel
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Brazil as a world-class biodiesel exporter

BRAZILIAN BIODIESEL

- 2004, Brazilian government launched the National Program for Production and Use of Biodiesel - NPPUB.
- In 2005, law 11.097 mandating a blend of 2% of biodiesel in the mineral diesel for 2008 (B2) and 5% for 2013 (B5).

  → 1 billion liters in 2008: 2.4 billion liters in 2013.
- Main objectives:
  - → Fuel supply diversification
  - → Social development.

ECONOMIC PERFORMANCE: SALES AND PRODUCTION

- 14 biodiesel plants in operation
- Production capacity of 600,000 ton/year.
- B2 diesel is offered by 2,000 gas stations
- About 60 projects for new biodiesel plants have been announced.
- Government and private agents expects to achieve the same technological and economic performance of ethanol production.

ECONOMIC PERFORMANCE: FEEDSTOCKS

Feedstock	Main Advantages	Main disadvantages
Soybeans 	Large availability Experience Unused vegetal oil capacity	Large scale monoculture Oil is a byproduct Price volatility
Castorbeans 	Family Crop Potential to increase production	Lack of agronomic knowledge and experience High oportunity cost of castor oil

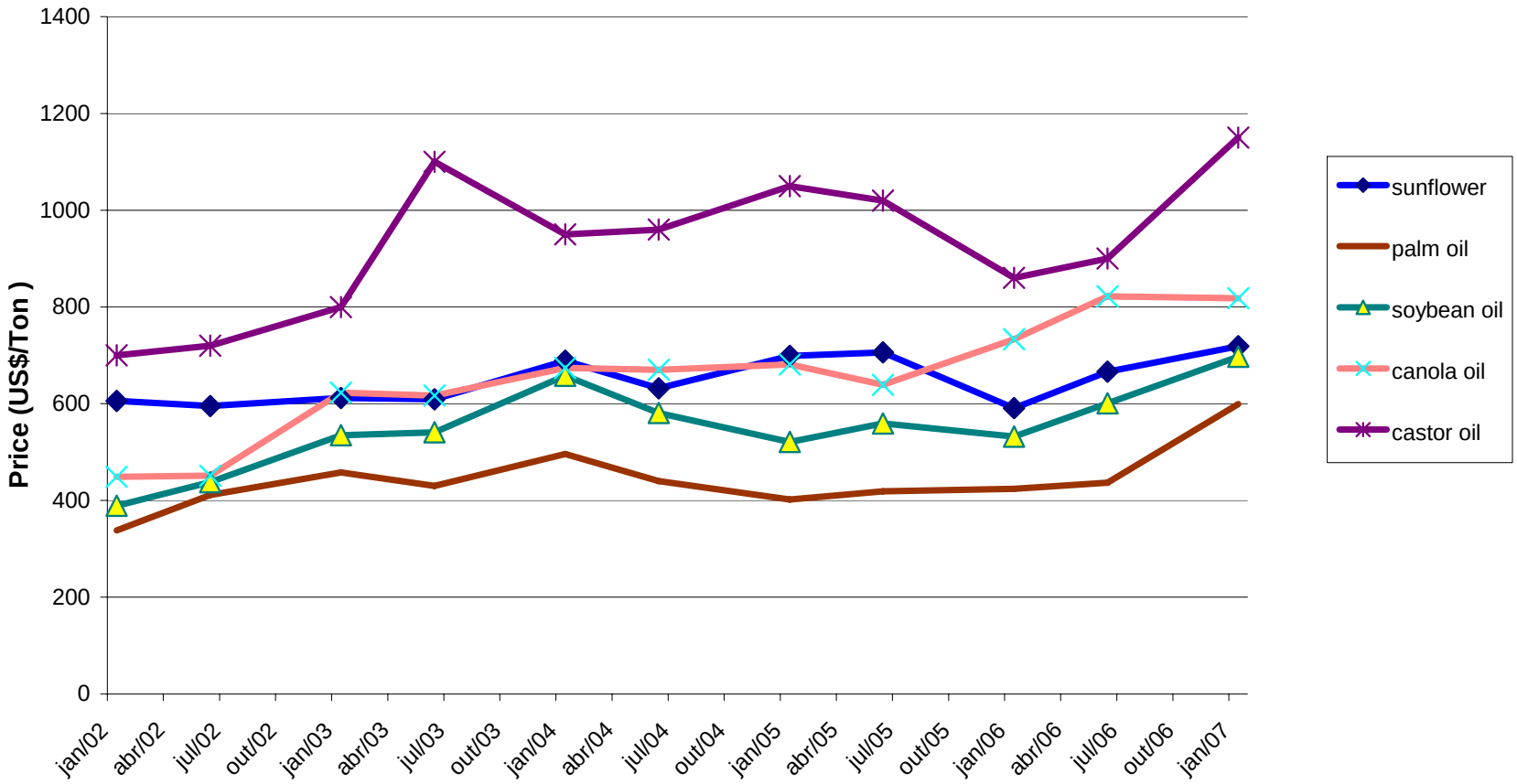
ECONOMIC PERFORMANCE: FEEDSTOCKS

FEEDSTOCK	MAIN ADVANTAGES	MAIN DISADVANTAGES
Palm Oil  	Largest oil productivity Potential to increasing production	Lack of agronomical research Suitable lands in Amazon area
Jatropha  	Low production cost Suitable land in dry areas	No commercial use Still in experimental phase
Tallow 	Large availability By-product from meat production	Use in low-cost industrial food (soups)

ECONOMIC CHARACTERISTICS OF MAIN SOURCE OF FEEDSTOCK FOR BIODIESEL IN BRAZIL

Feedstock	Current Availability	Level of agronomical research	Potential Social benefit	Oil content % of dry weight	Biomass productivity (tons per hec	Oil productivity (liters per hec)	Brazilian production (1000 tons - 2005)
Soybean	Assured	High	Low	20	2,230	440	51,182
Tallow	Significant	n. a.	Low	-	-	-	1,000
Palm	Limited	Low	High	20	20,000	4,000	151
Jatropha	Non existent	Low	High	30-40	n.a.	n.a.	0
Castor	Limited	Low	High	47	730	343	168
Cotton	Significant	High	High	15	3,000	450	3,666
Sunflower	Limited	High	Low	40	1,500	630	23

EVOLUTION OF VEGETAL OIL PRICES

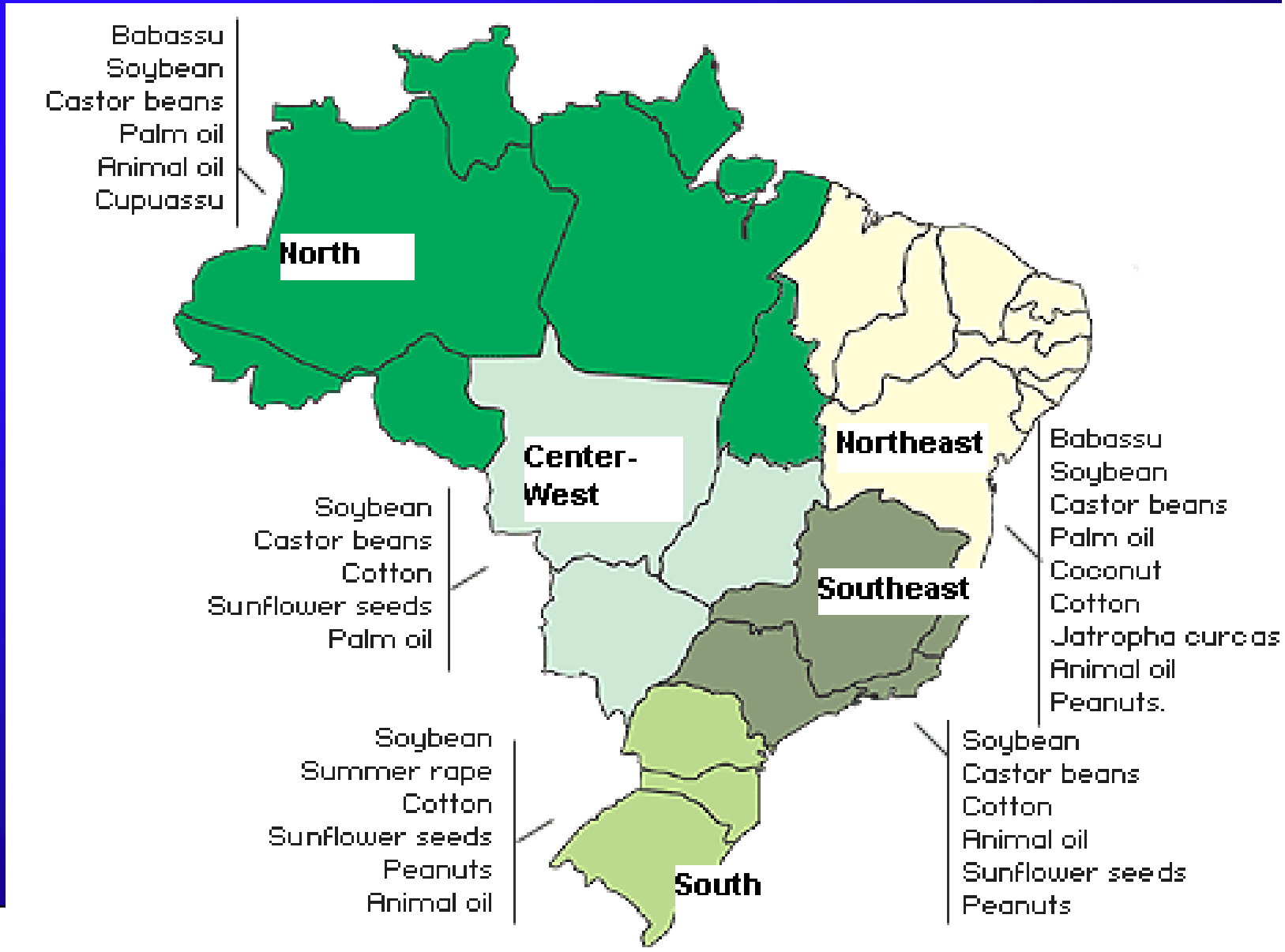


IN SEARCH FOR A BIODIESEL ECONOMIC MODEL

Soybean harvesting in Mato Grosso

Castor bean harvesting in the Northeast

FEEDSTOCK DIVERSITY



BIODIESEL TECHNOLOGY - 1

- Diversity in feedstock supply
- Availability of ethanol
- Uncertainty regarding biodiesel market and feedstock opportunity costs
  - ➔ Search for biodiesel plant flexibility in terms of feedstock use
  - ➔ Discontinuous production
  - ➔ Small scale plants: average size of plants: 50 thousands tons/year
  - ➔ Search for replacement of methanol by ethanol

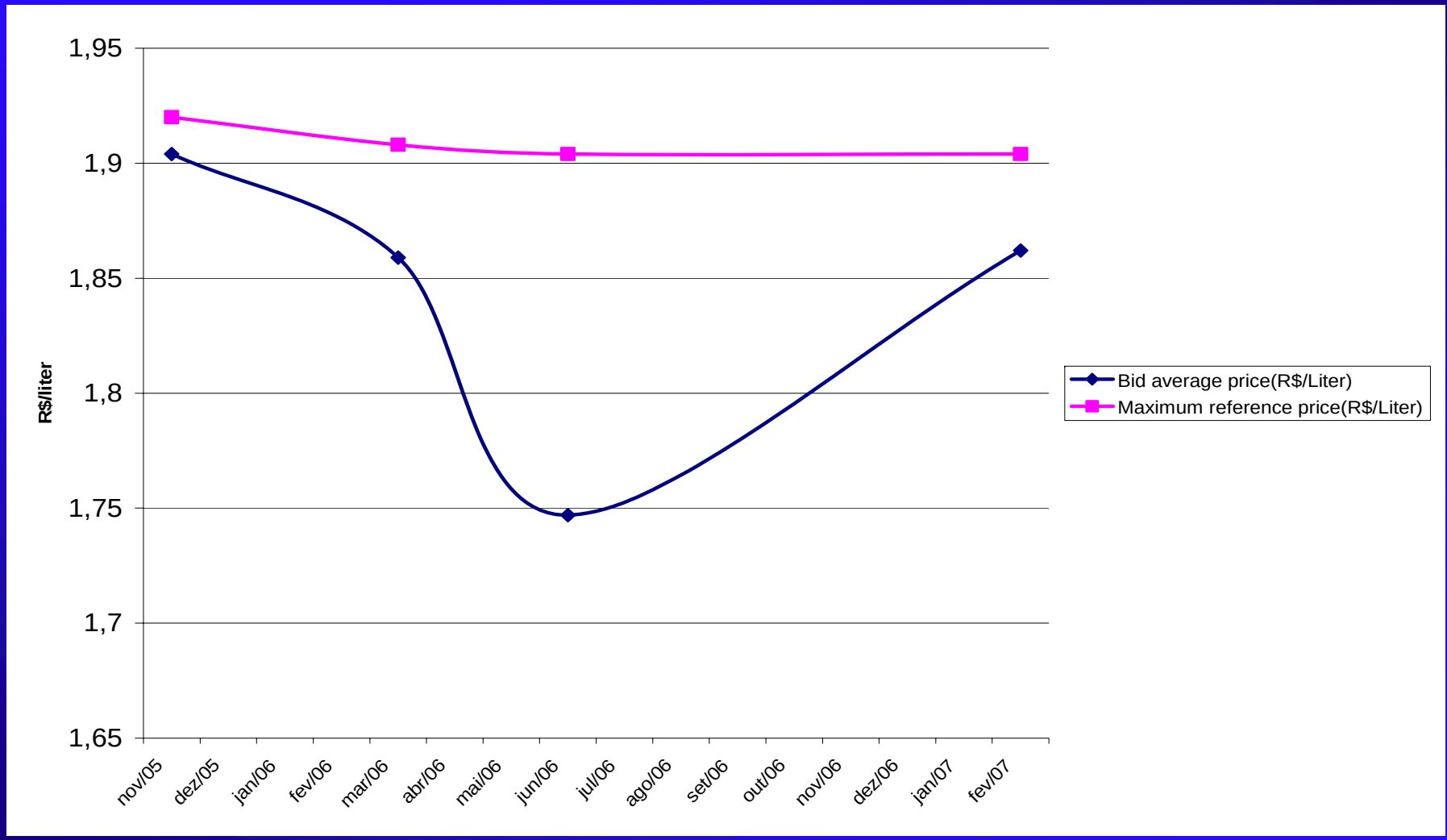
BIODIESEL TECHNOLOGY - 2

- Another important technology: H-Bio
  - ➔ Announced by Petrobras, will be in place in 2008
  - ➔ Production of diesel out of a mixture of mineral diesel and vegetal oil in Hydro treatment Units
  - ➔ Use of installed refinery unit capacity
  - ➔ Reduction of Mineral diesel imports
  - ➔ No impact in exhaust emissions since diesel produced is equal to mineral diesel

BIODIESEL PUBLIC AUCTIONS

- Objective: Organize market place and stimulate investments
  - ➔ Temporary incentive
- Buyers: Petrobras
- Sellers: biodiesel producers that fulfill social requirements
  - ➔ Actual or future production
- 5 Auctions so far (February 2007)
  - ➔ 885 million liters
  - ➔ Price paid to biodiesel producers: from US$ 0.83/litre and US$ 0.9/ liter.
  - ➔ Mineral Diesel pump prices US$ 0.9/ litre

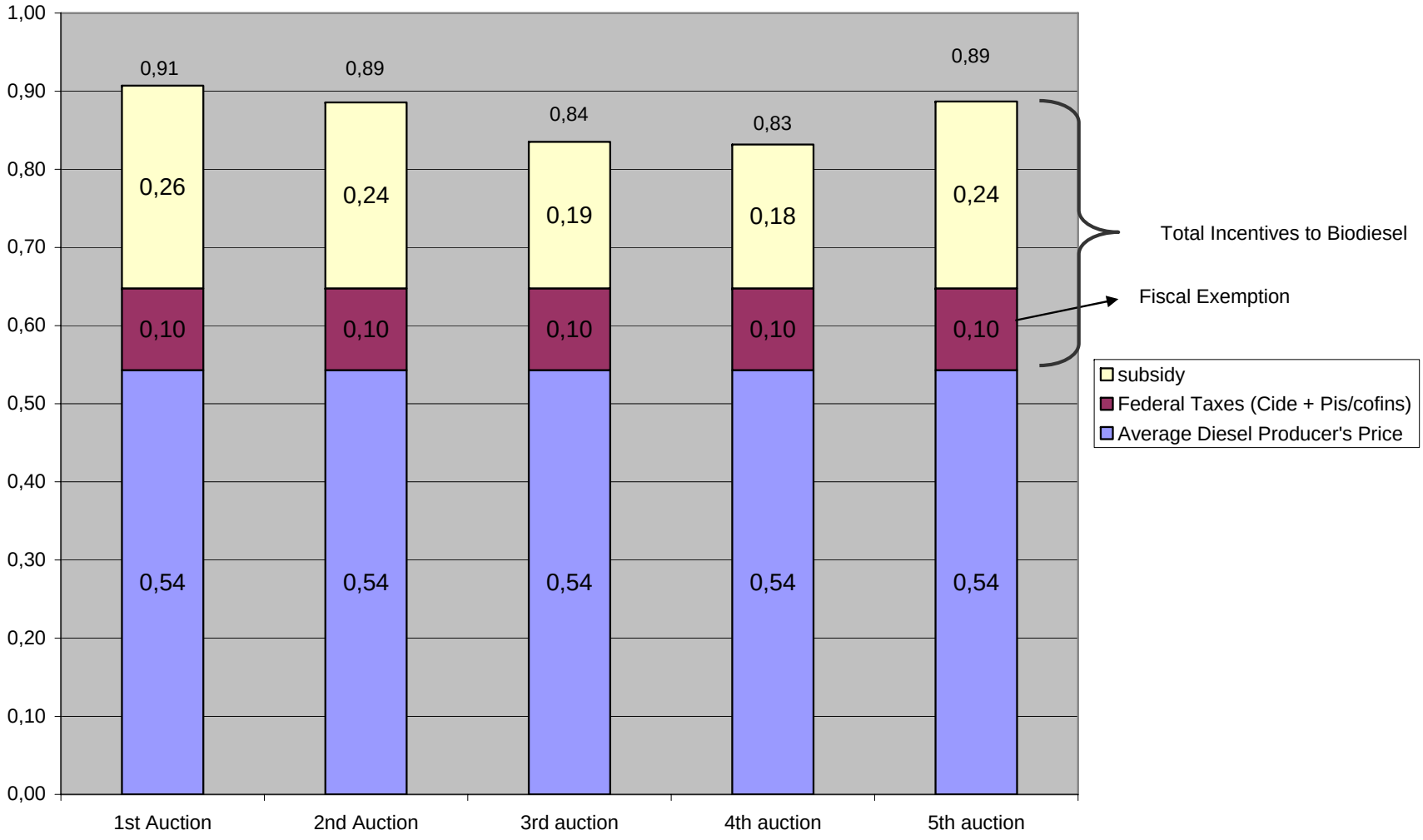
EVOLUTION OF BIODIESEL PRICE IN THE ANP´S AUCTIONS



TOTAL INCENTIVES TO BIODIESEL

- Price paid in auctions
  - ➔ According to CEPEA, biodiesel production costs in Brazil vary from US$ 0.34 to US$ 0.85 (40,000 tons/year plant)
- Different levels of federal tax exemptions – regional and social development
  - ➔ mineral diesel pays a total federal tax of approximately $0.10 par liter.
  - ➔ 31% tax reduction to biodiesel produced from castor or palm oils and from agribusiness producers in North, Northeast or “Semi-arid” areas.
  - ➔ Small farm producers in any country region with any oilseed are granted a 68% tax reduction.
  - ➔ Small farmers that produce with castor/palm oils or are located in North, Northeast or “Semi-arid regions” are totally exempted from federal taxes.

SUBSIDIES TO BIODIESEL PRODUCTION IN BRAZIL (US$ PER LITER)



OUTLINE

- Ethanol
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Social performance;
  - ➔Energy security performance;
  - ➔Brazil as a world-class ethanol exporter
- Biodiesel
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Brazil as a world-class biodiesel exporter

ENVIRONMENTAL PERFORMANCE

Energy Balance for Different type of Biodiesel Feedstock

Feedstock	Energy input/output
Soybean	1.5 – 3.2
Palm tree	5 – 10
Jatropha	5-6
Castor beans	2-2.9
Sunflower	3

Source: Own Elaboration, base on the literature quoted above

Literature on other biodiesel environmental impacts requires further development

ENVIRONMENTAL PERFORMANCE

- According to La Rovere (2006), each liter of mineral diesel in Brazil emits about 2.7 kg of CO2.
- If we assume biodiesel contributint to 60% reduction in CO2 emissions, evoided emissions will be:
  - ➔ about 1.3 million tons of CO2 per year in 2008 (B2)
  - ➔ about 3.9 million tons in 2011 (B5).
  - ➔ as the share of other types of biodiesel feedstocks increases in the Brazilian production, further reduction in CO2 emissions can be obtained

BIODIESEL IMPACTS ON DEFORESTATION

- Biodiesel can have a direct impact on deforestation
  - ➔ Soybean plantation in Amazon area is increasing
  - ➔ Palm oil production
- Indirect impact
  - ➔ indirect association between deforestation and soybean production in Brazil
  - ➔ soybean producers prefer to use areas already deforested by cattle raising activity

OUTLINE

- Ethanol
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Social performance;
  - ➔Energy security performance;
  - ➔Brazil as a world-class ethanol exporter
- Biodiesel
  - ➔Economic performance;
  - ➔Environmental performance;
  - ➔Brazil as a world-class biodiesel exporter

OTHER ENVIRONMENTAL IMPACTS

- Local impacts of soybean plantation
  - → Soil degradation
  - → Water pollution
  - → Decrease in biodiversity
- Biodiesel has a positive impact on local emission
  - → Diesel consumption is the most important contributor to the poor air quality in Brazilian large cities
  - → Biodiesel emissions reductions:
  - → Carbon Monoxide (CO) → 50%
  - → Hydrocarbon (HC) → 70%
  - → Sox emissions → 100%
  - → NOx emissions increases by 10%.
- Social avoided cost of B5 estimated at US$ 75 millions

BRAZIL AS A WORLD-CLASS BIODIESEL EXPORTER

- Investment requirement for creating an important biodiesel production capacity in Brazil is modest
  - ➔ important production of soybean.
  - ➔ Significant available capacity for vegetal oil production
  - ➔ Biodiesel plants costs are lower than ethanol plants
  - ➔ The total investment in the 60 projects announced in Brazil was estimated in about US$ 800 millions
- The mandatory biofuels standards in represent an important market potential for Brazil
- Exports will depend on how production costs will evolve. Necessary to increase alternative feedstock production
- Biodiesel specification is not yet on place for allowing the development of international market
- Biodiesel environmental certification will be necessary

BRAZILIAN BIODIESEL PRODUCTION – A SPECULATIVE SCENARIO

	Area (million hectares)	Biodiesel Productivity (l /ha)	Annual production (million liters)
Castor beans	1.5	556	834
Palmtree	1.5	3,600	5,400
Jatropha	1.5	360	540
Sunflower	1.5	937	1,405
Soybean	4.4	662	2,913
Total	10.4		11,082