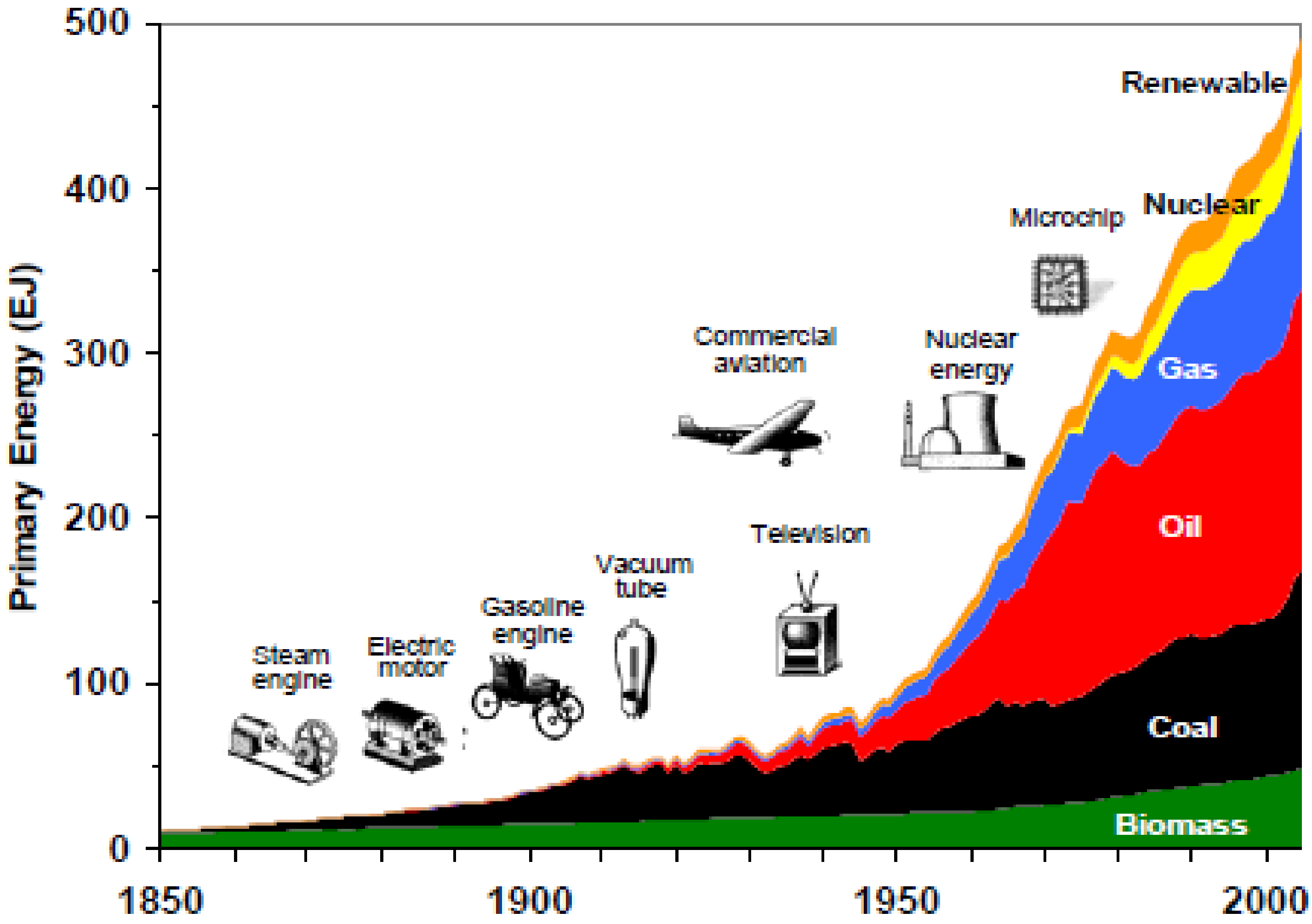
ABC/IAC Biofuels Workshop

may 24

Bioenergy in Brazil.

Prof. José Goldemberg



Primary Energy (EJ)
500
400
300
200
100
0
1850
1900
1950
2000
Renewable
Nuclear
Gas
Oil
Coal
Biomass
Steam engine
Electric motor
Gasoline engine
Vacuum tube
Television
Commercial aviation
Nuclear energy
Microchip

World Primary Energy Supply (2008)
Shares of 516 EJ

Modern Biomass	EJ	%
Bioethanol	1.7	0.32
Biodiesel	0.5	0.09
Bioelectricity	3.6	0.70
Heat	3.7	0.71

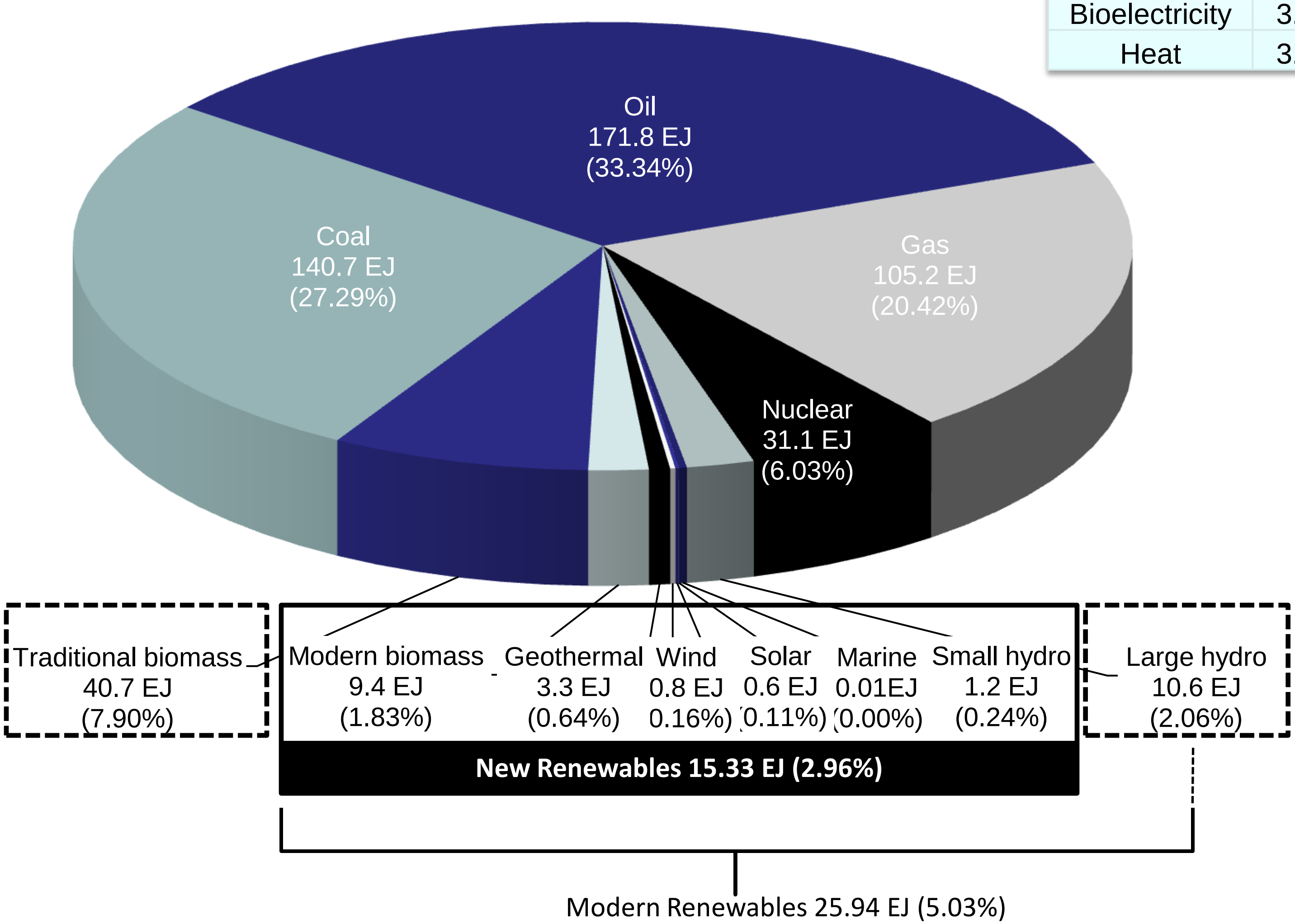
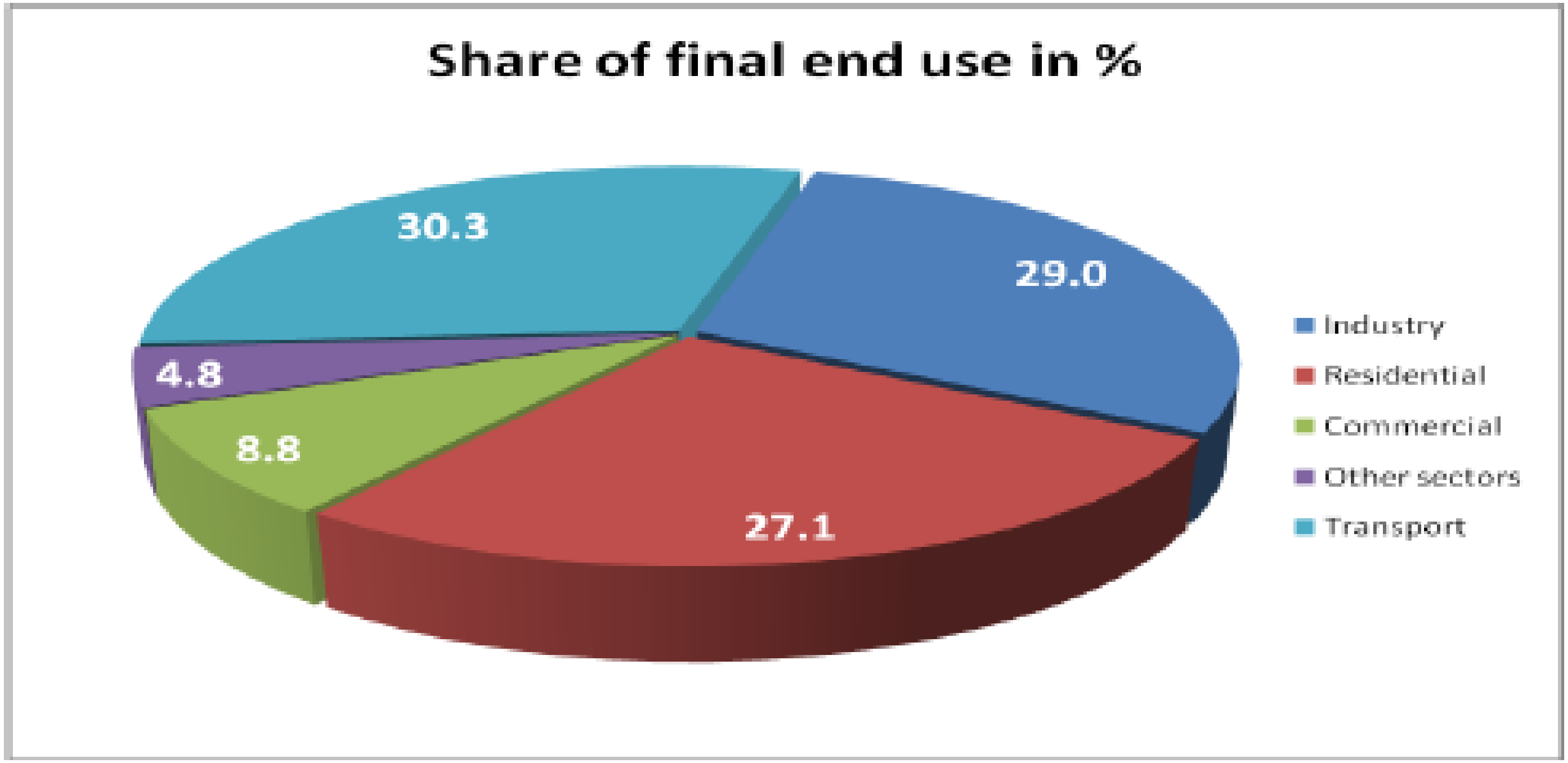


Figure 1. Energy consumption in different sectors.



According to the IEA statistics for energy balance for 2004-2005,(2007 edition), the total final energy use globally accounts for 7209 Mtoe (Mega Tonnes Oil Equivalents).The residential and commercial sectors account for respectively 1951 Mtoe and 638 Mtoe, which is almost 40 % of the final energy use in the World[1]. The major part of this consumption is in buildings.

Problemas com o atual sistema energético

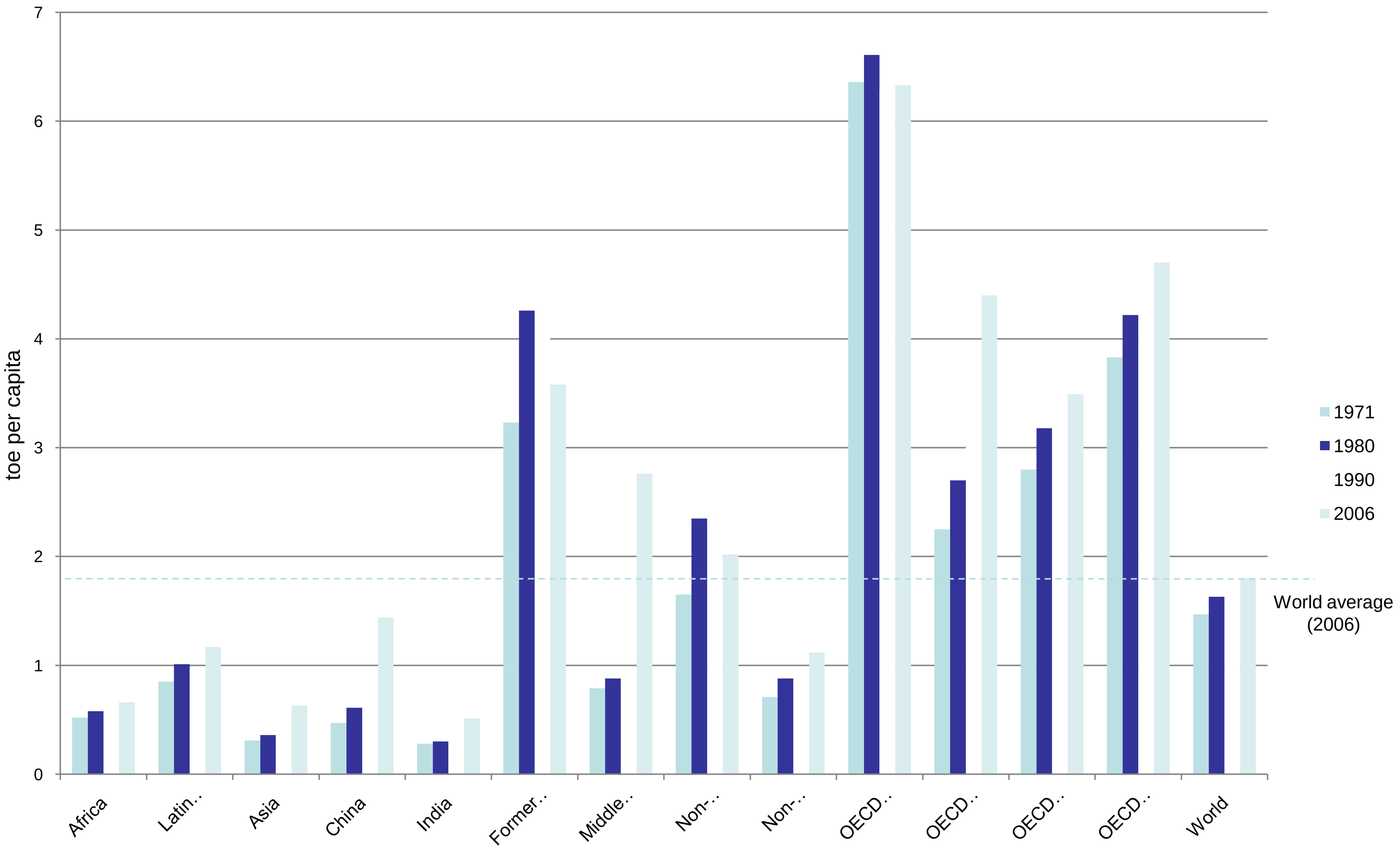
i. Equidade

ii. Exaustão das reservas

iii. Segurança de abastecimento

iv. Impactos ambientais

TPES/population (toe per capita)



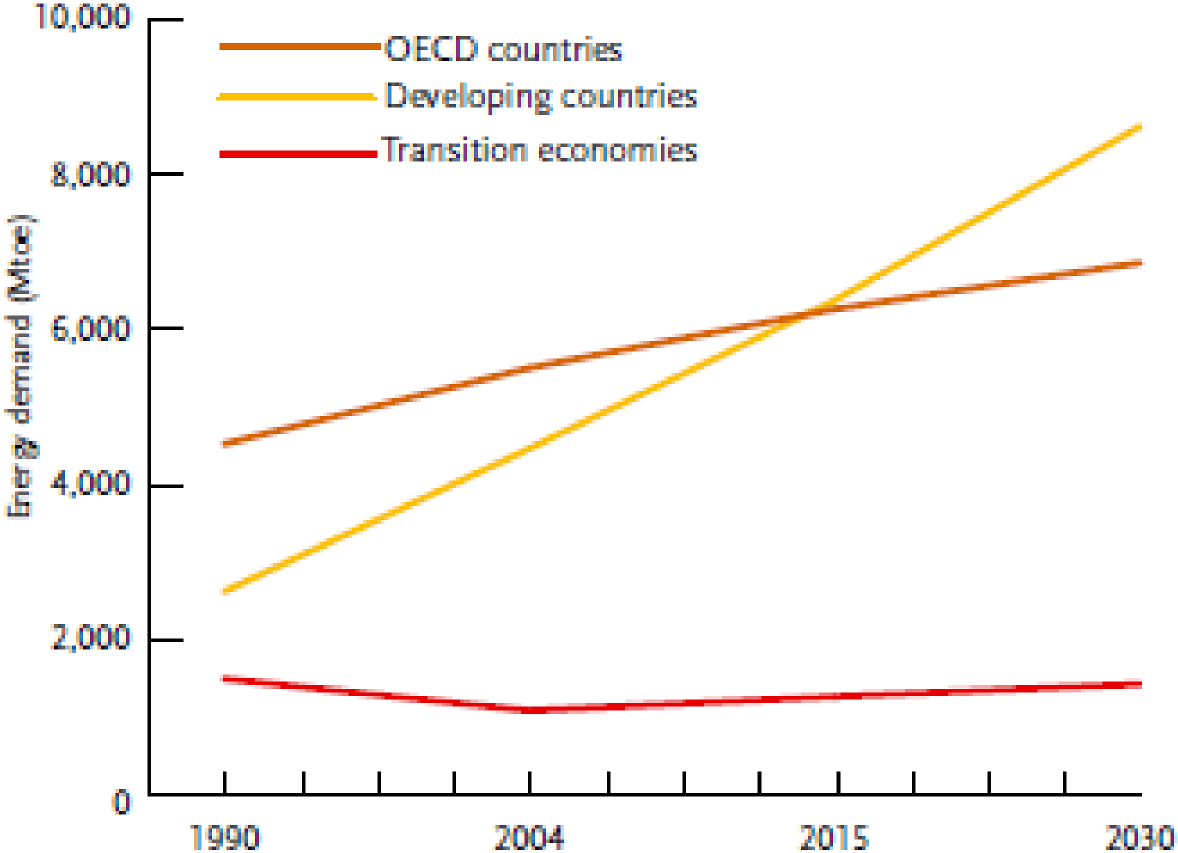


Figure 1.2 Regional shares in world primary energy demand, including business-as-usual projections

FACING THE CHALLENGE

- Energy efficiency at the source and end-uses
- Renewables
- New technologies

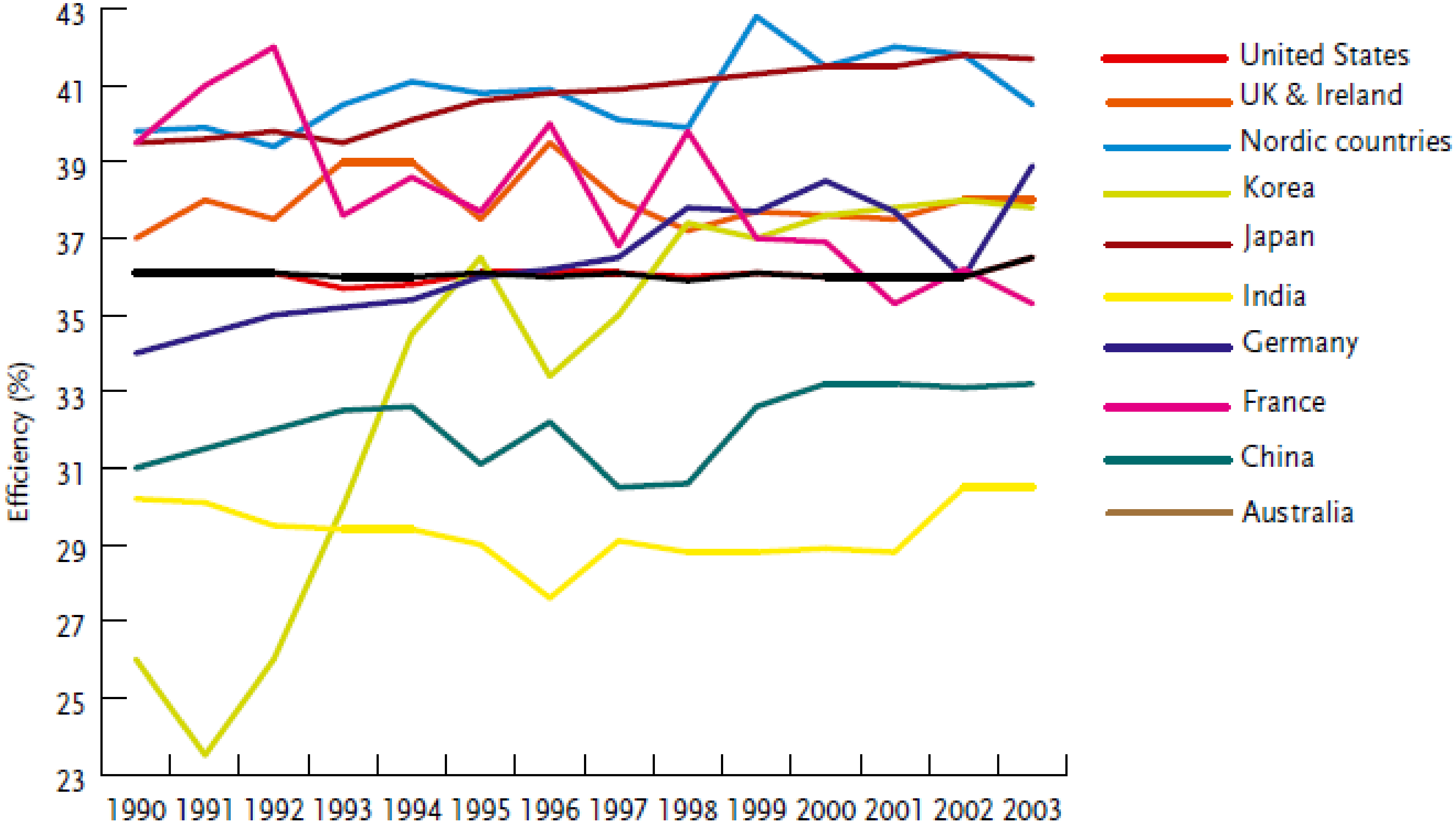


Figure 3.1 Efficiency of coal-fired power production

Source: Graus and Worrell, 2006.

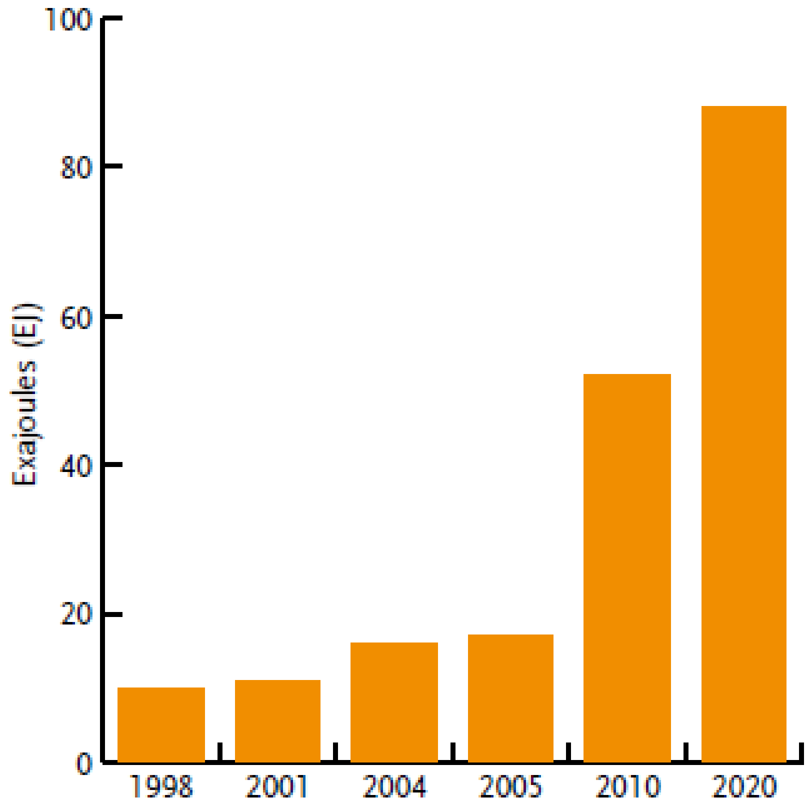


Figure 3.7 Modern renewables projections for 2010 and 2020

Note: Projections of modern renewables (including small hydro, excluding large) based on 11.5 percent growth per year, over the period 2001-2005.

Sources: UNDP, UNDESA, and WEC, 2000 and 2004; REN21, 2006; And IEA, 2006

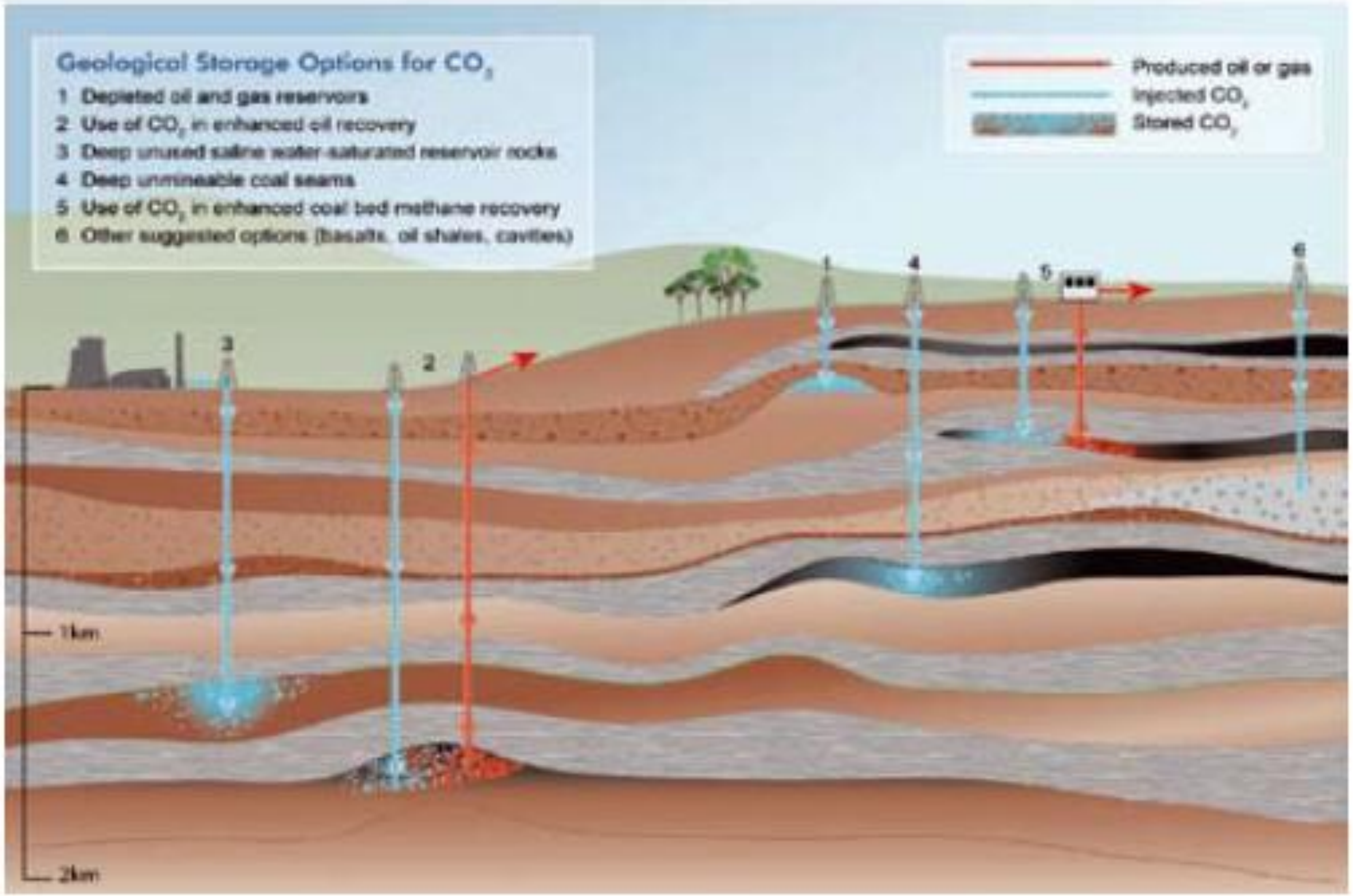
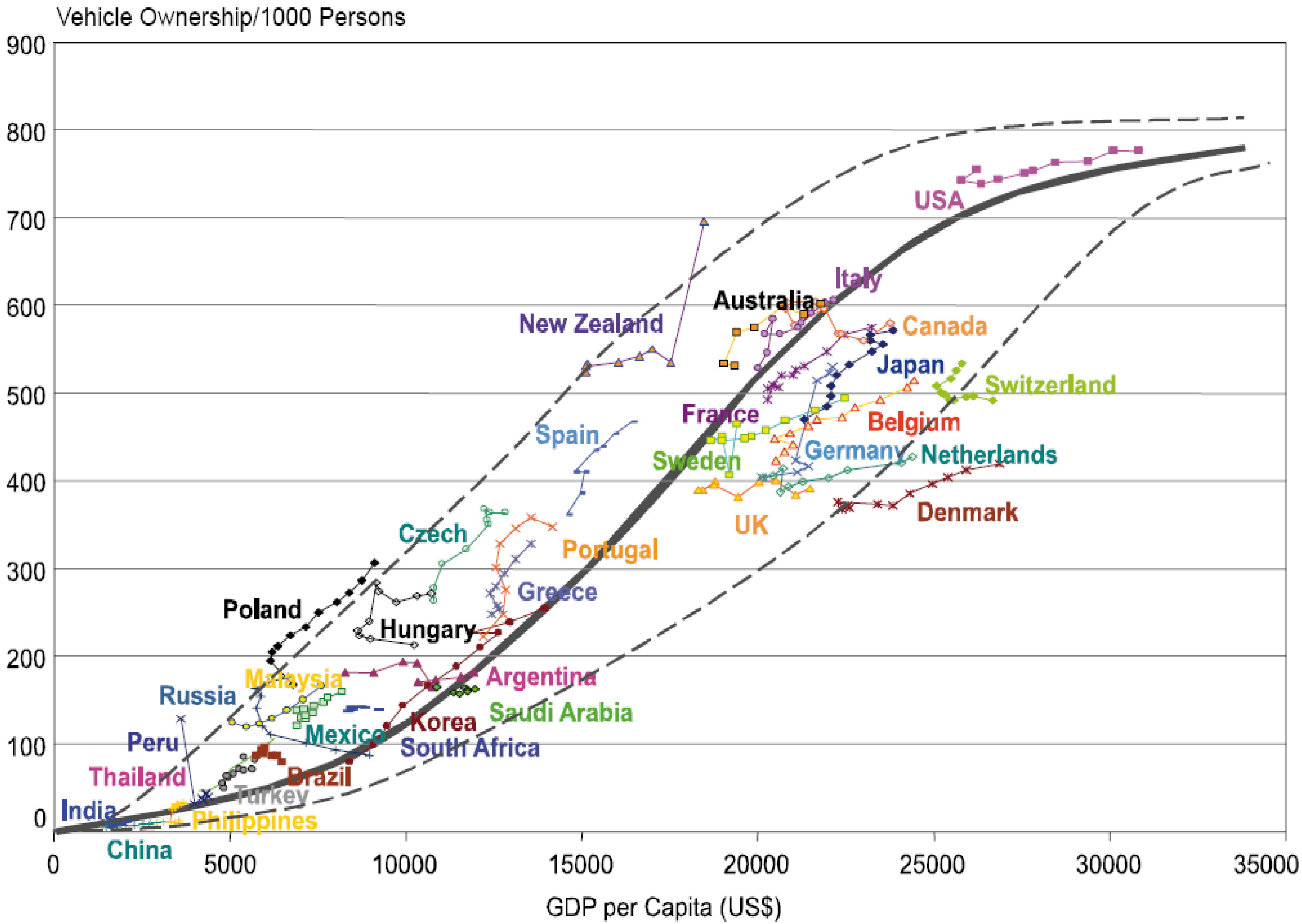


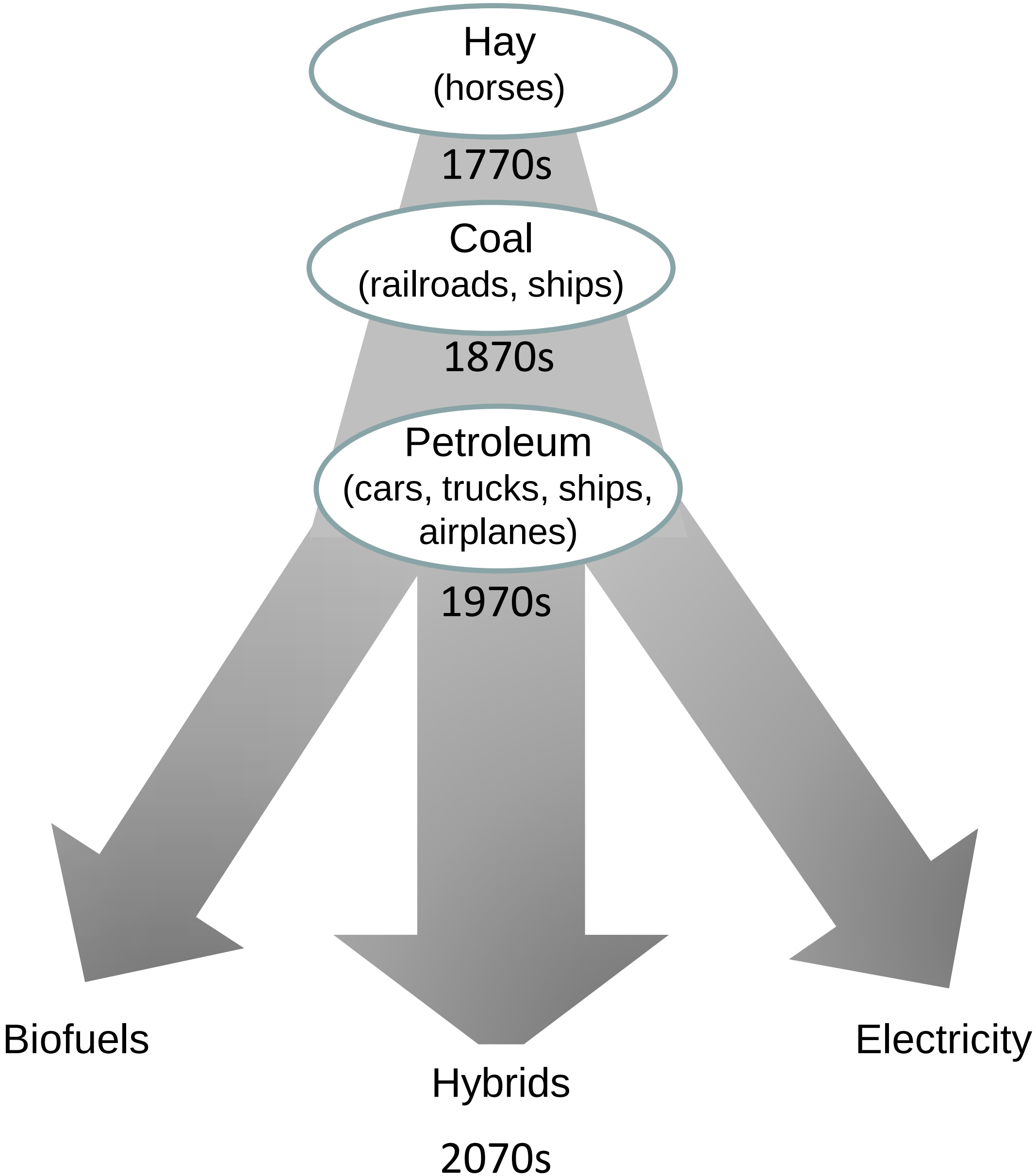
Figure 3.3 Schematic illustration of a sedimentary basin with a number of geological sequestration options

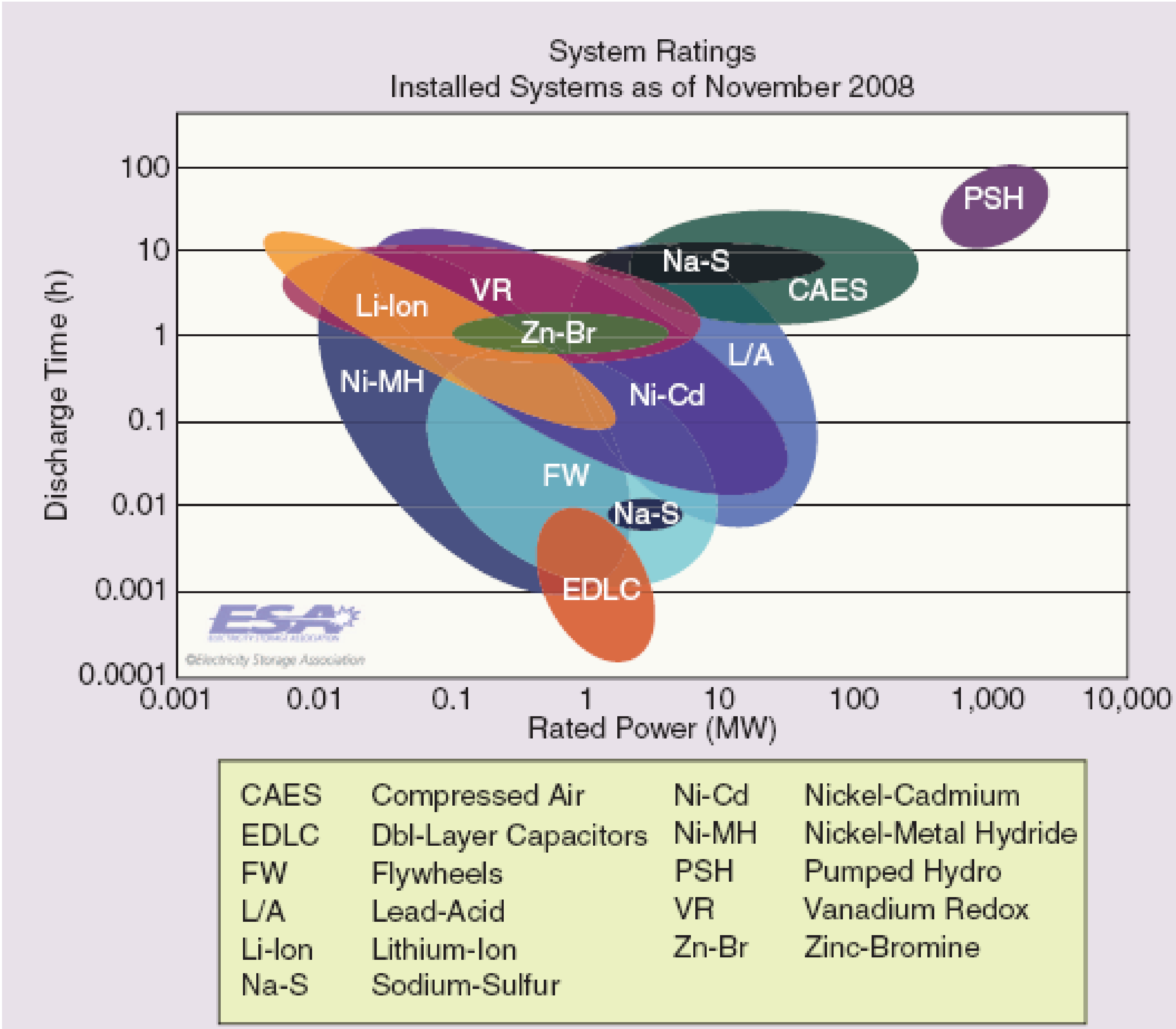
Source: IPCC, 2005



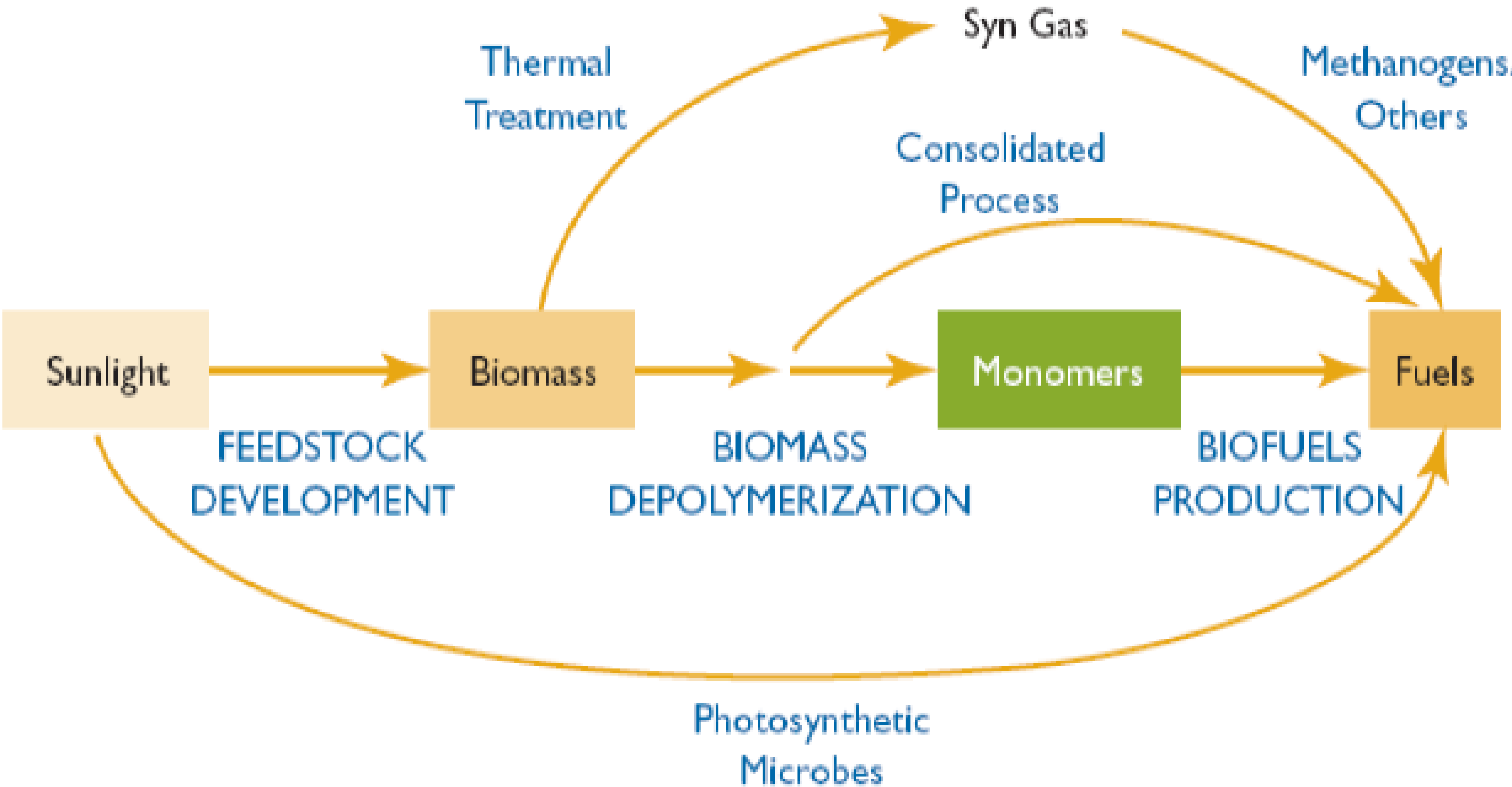
Vehicle Ownership/1000 Persons
900
800
700
600
500
400
300
200
100
0
0
5000
10000
15000
20000
25000
30000
35000
GDP per Capita (US$)
USA
Italy
Australia
New Zealand
Canada
Japan
Switzerland
France
Belgium
Spain
Germany
Netherlands
Sweden
UK
Denmark
Czech
Portugal
Greece
Poland
Hungary
Malaysia
Argentina
Russia
Saudi Arabia
Korea
Mexico
Peru
South Africa
Thailand
Brazil
Turkey
India
Philippines
China

The Evolution of Transportation

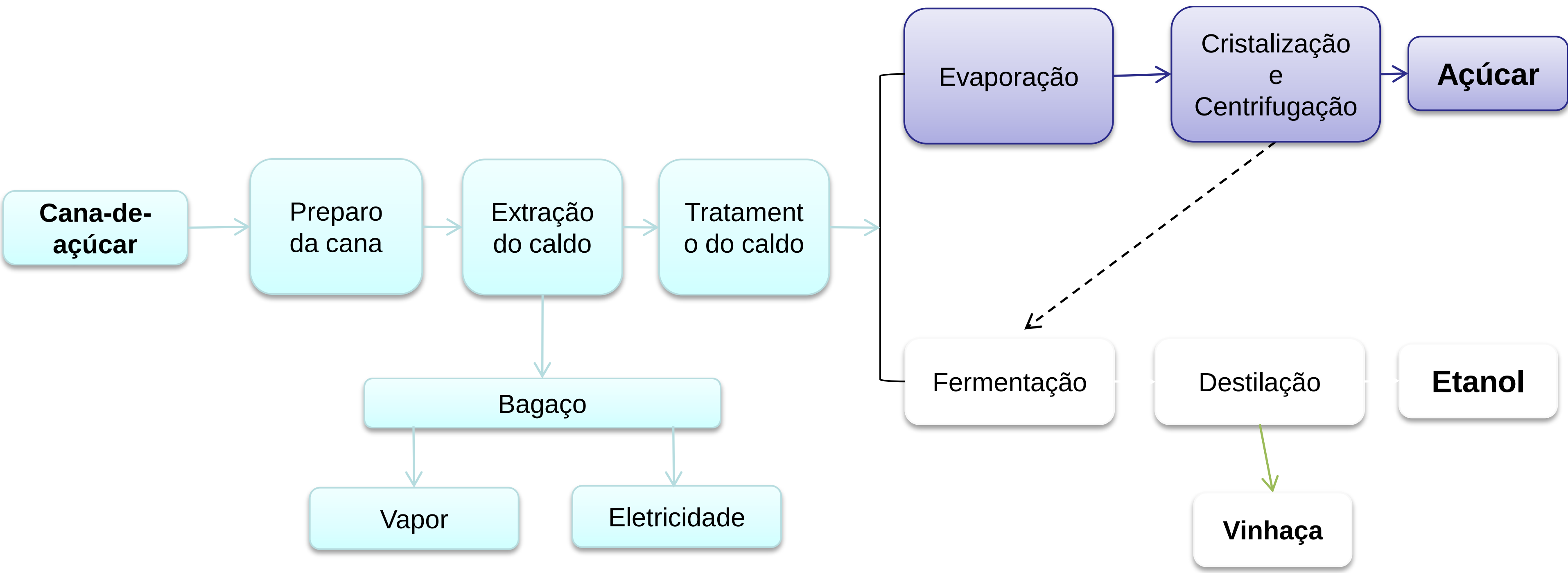



System Ratings
Installed Systems as of November 2008
Discharge Time (h)
100
10
1
0.1
0.01
0.001
0.0001
0.001
0.01
0.1
1
10
100
1,000
10,000
Rated Power (MW)
PSH
Na-S
CAES
VR
Li-Ion
Zn-Br
L/A
Ni-MH
Ni-Cd
FW
Na-S
EDLC
©Electricity Storage Association
CAES Compressed Air
EDLC Dbl-Layer Capacitors
FW Flywheels
L/A Lead-Acid
Li-Ion Lithium-Ion
Na-S Sodium-Sulfur
Ni-Cd Nickel-Cadmium
Ni-MH Nickel-Metal Hydride
PSH Pumped Hydro
VR Vanadium Redox
Zn-Br Zinc-Bromine

Biomass fuel production



Fluxograma do Processo de Produção de Açúcar e Etanol



“Birth certificate” of the Ethanol Program in Brazil

I. The expansion of ethanol production

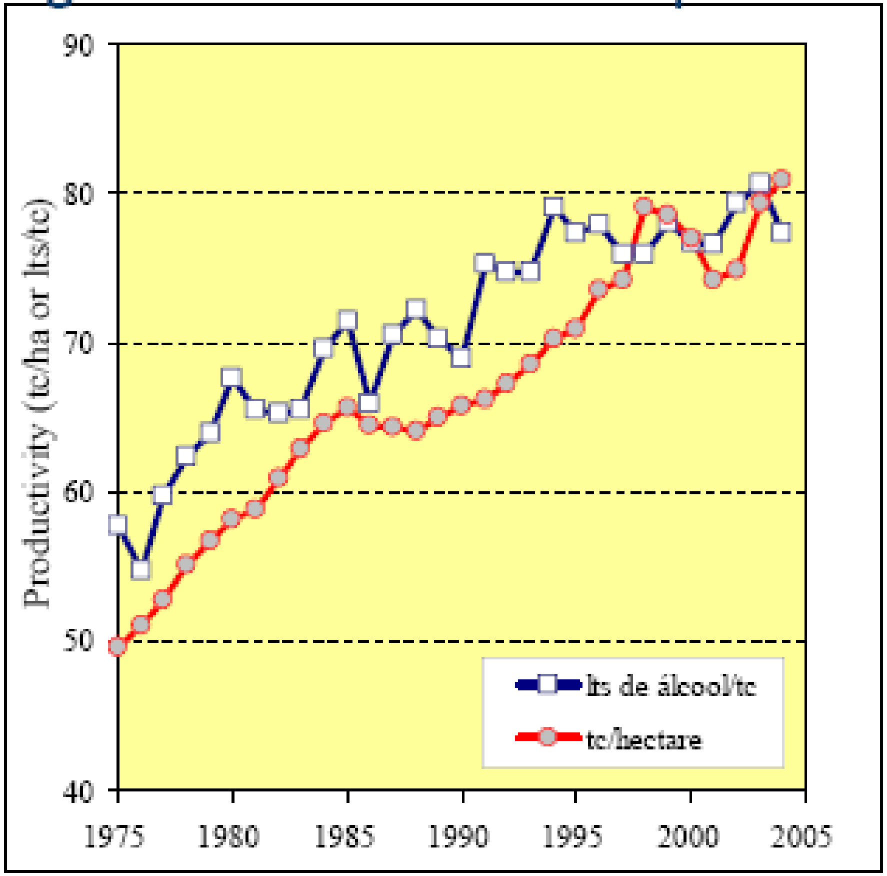
Decree 76593 (November 14,1975)
The price of ethanol should be at parity with sugar and 35% higher than the price of 1kg of sugar

II. The expansion of ethanol consumption

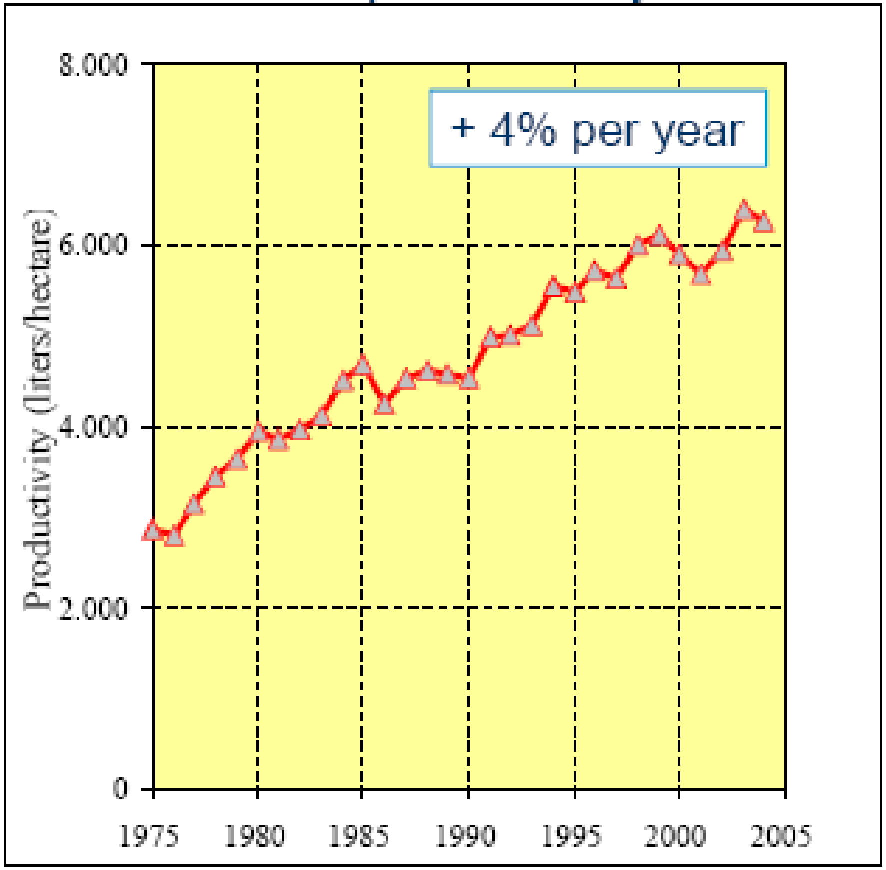
Mandates for the amount of ethanol mixed into the gasoline (25% today).
Setting the price of ethanol paid to the producers at 59% of the selling price of gasoline.

Increase in productivity through R&D

Agricultural and Industrial product.



Total productivity



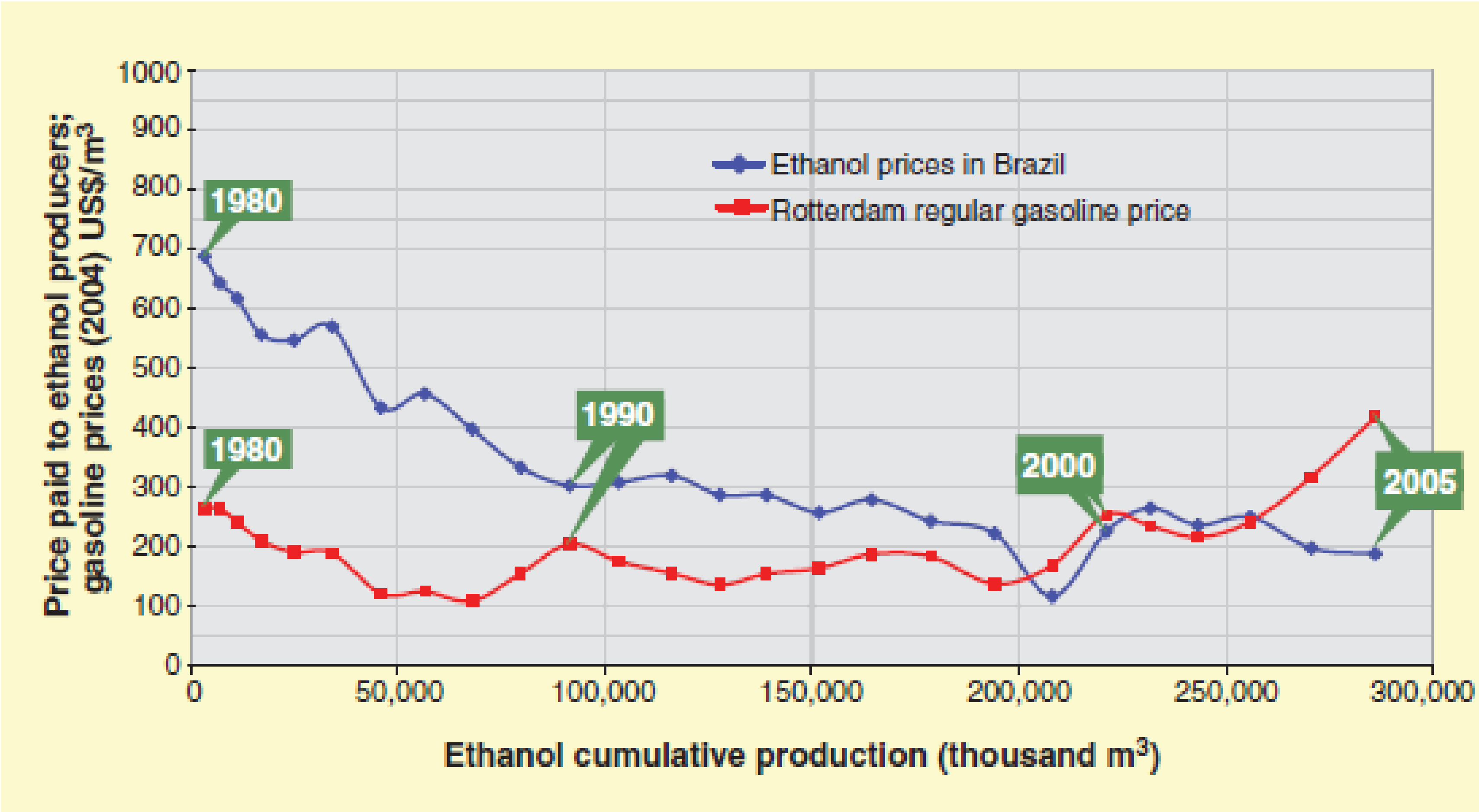
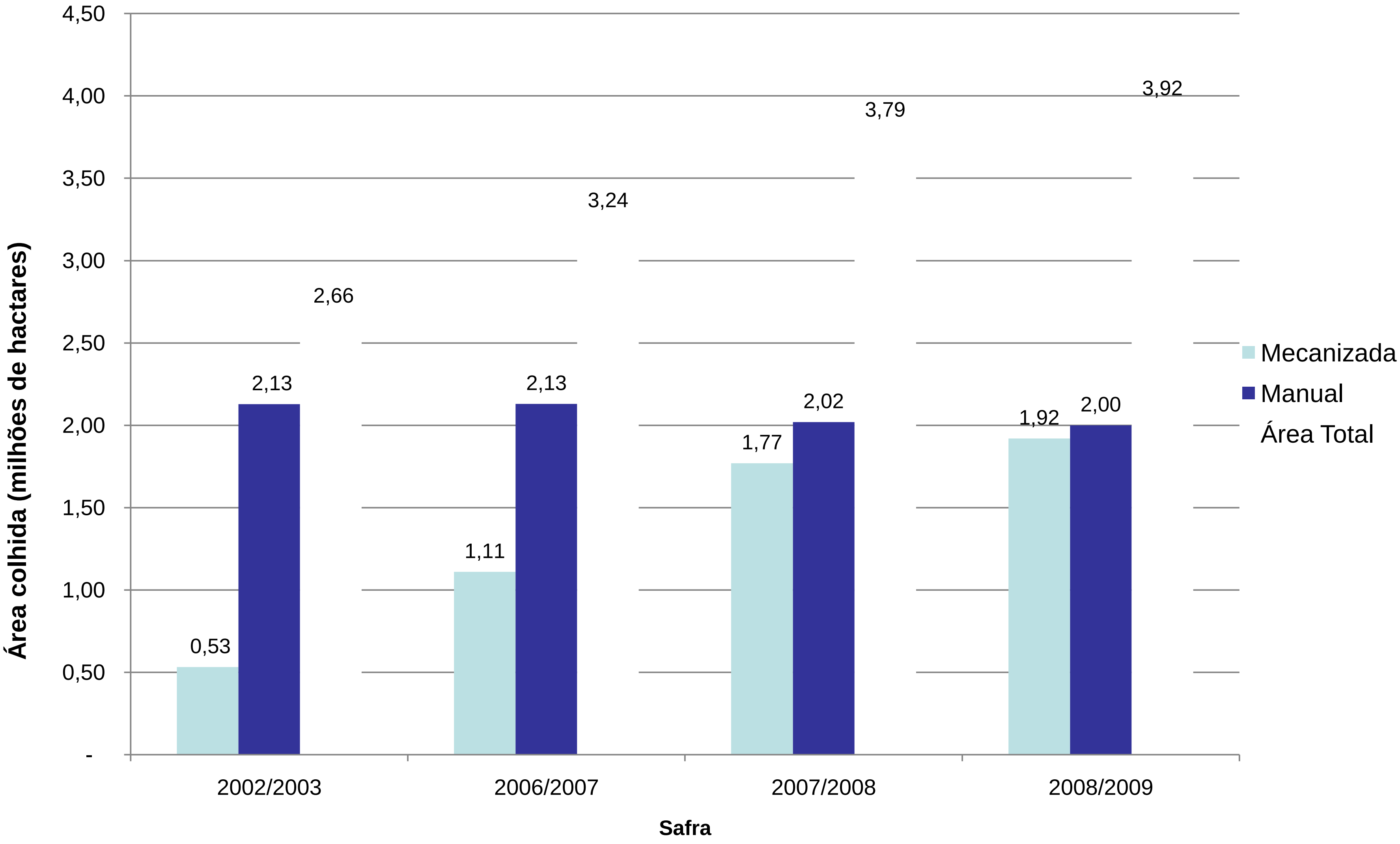


Fig. 2. Ethanol learning curve in volume, comparing the price paid to ethanol producers in Brazil with the price of gasoline in the international market of Rotterdam (*6*).

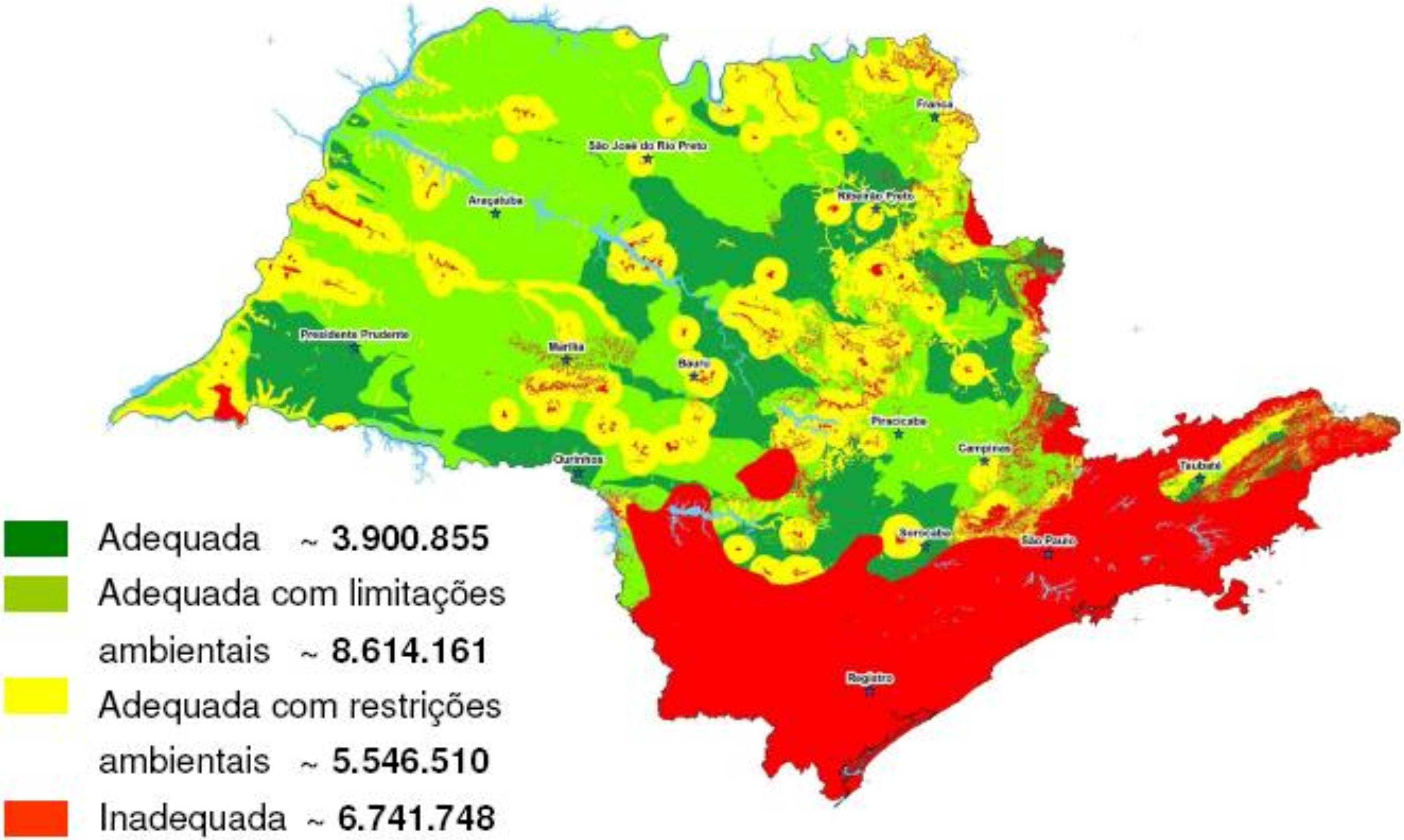
Present production and potential demand for ethanol

Country/region	Present gasoline consumption (billion liters per year) 2007	Present ethanol production (billion liters per year) 2008	Potential demand resulting from present mandates up to 2020/22 per year
US	530	34	136
European Union	148	2.3	8.51
China	54	1.9	5.4
Japan	60	0.1	1.8
Canada	39	0.9	1.95
United Kingdom	26	0.03	1.3
Australia	20	0.075	2.0
Brazil	25.2	27	50
South Africa	11.3	0.12	0.9
India	13.6	0.3	0.68
Thailand	7.2	0.3	0.7
Argentina	5.0	0.2	0.25
The Philippines	5.1	0.08	0.26
Total	943.2	67.3	209.75

Evolução da Colheita Mecanizada no Estado de São Paulo



Zoneamento Agroambiental para o Setor Sucroalcooleiro do Estado de São Paulo



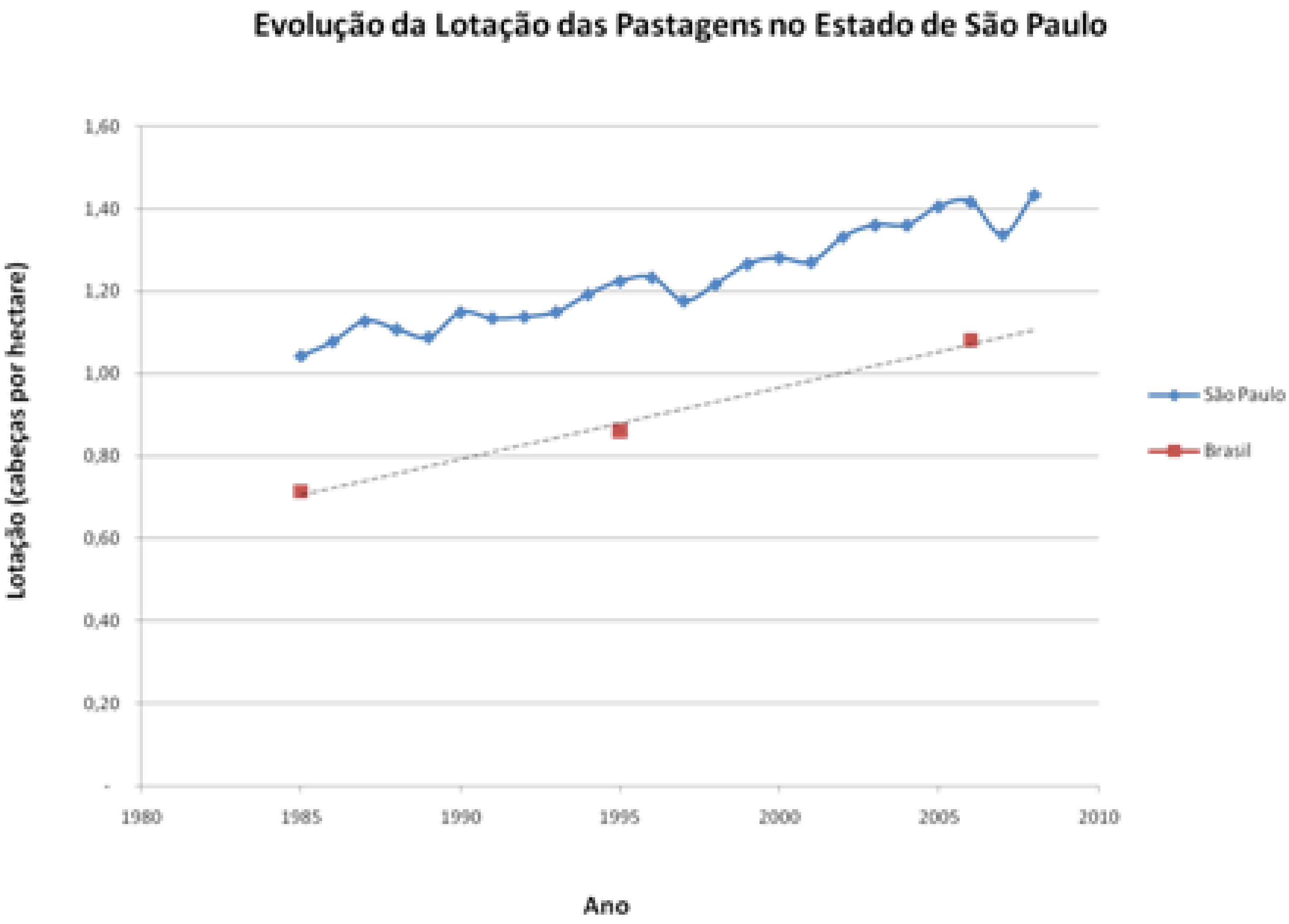
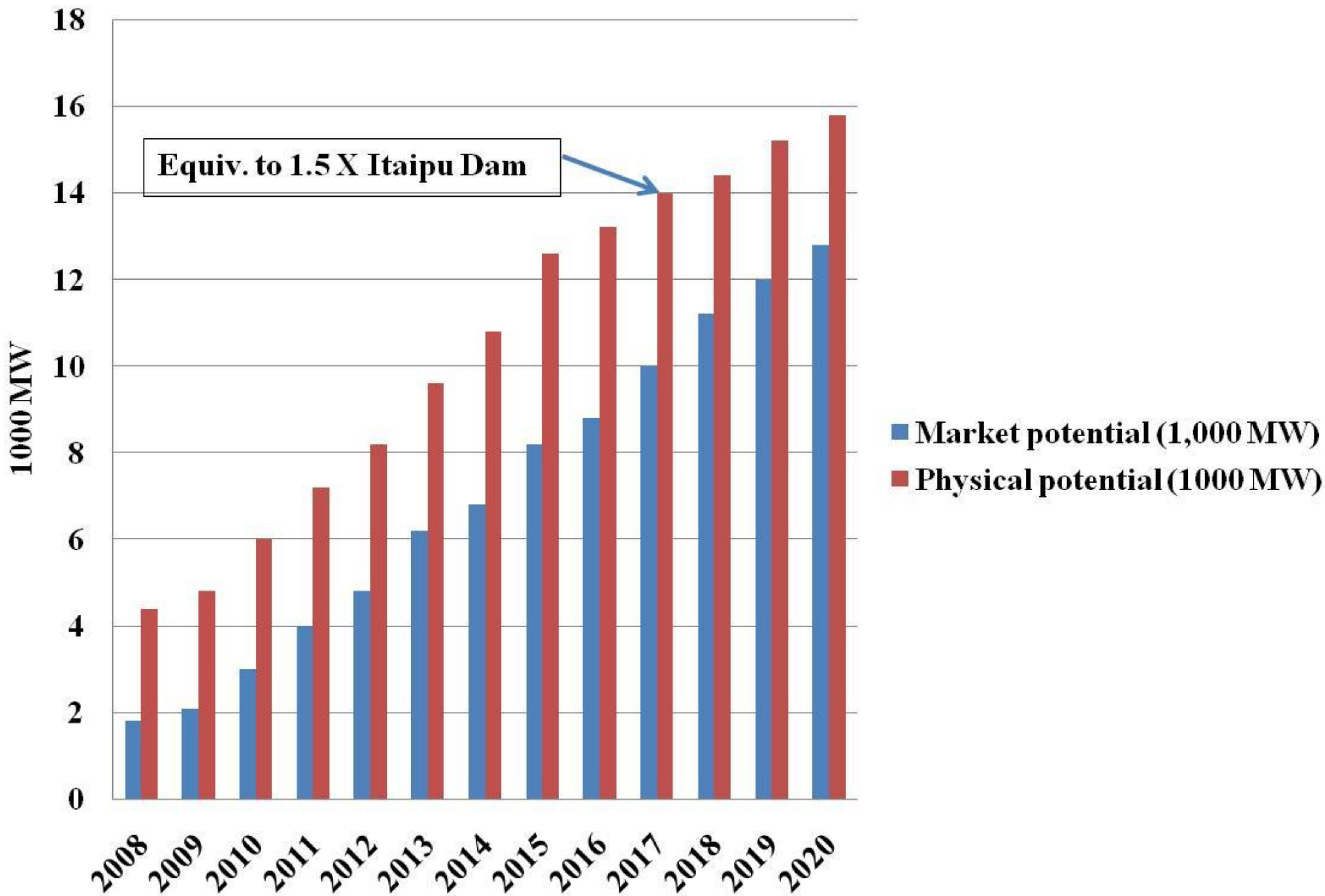
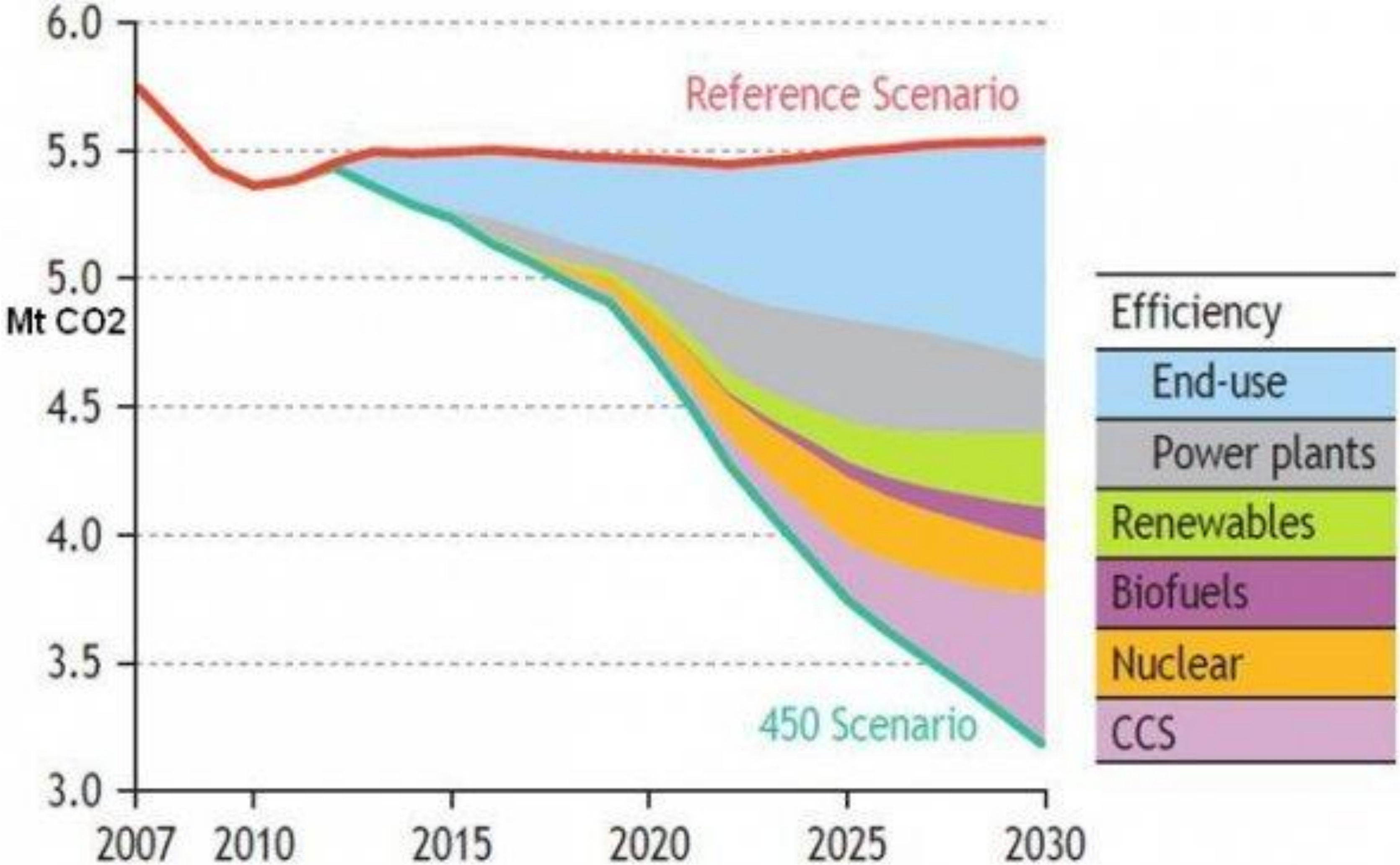

Evolução da Lotação das Pastagens no Estado de São Paulo
Lotação (cabeças por hectare)
1,60
1,40
1,20
1,00
0,80
0,60
0,40
0,20
-
1980
1985
1990
1995
2000
2005
2010
Ano
São Paulo
Brasil

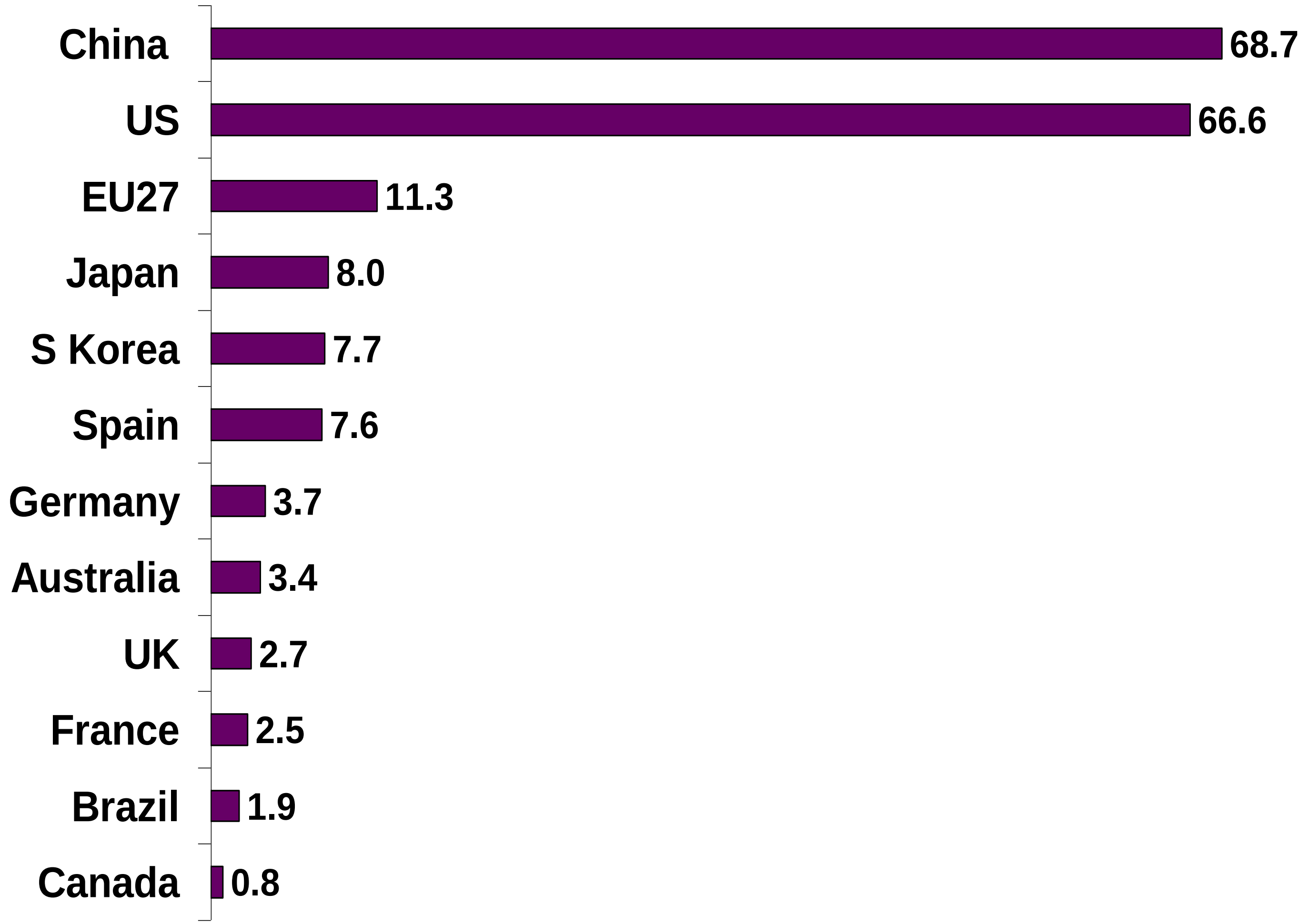
Figure 32 - Potential bioelectricity from sugar cane - Brazil 2008-2020



United States energy-related CO_2 emissions abatement



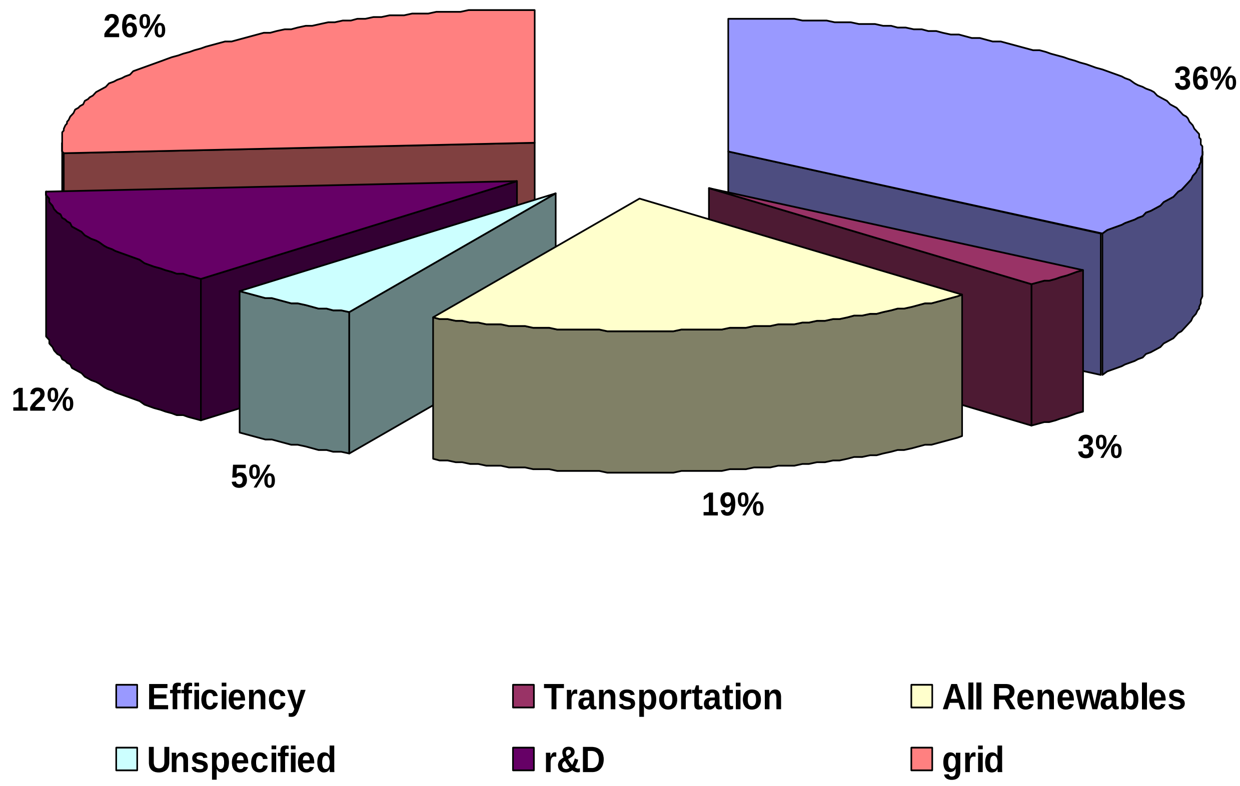
Green stimuli, ($bn)



Note: Total estimated amount announced by the 12 economies amounts to $ 184.9bn

Source: New Energy Finance

Sector break down of global green stimuli



Source: New Energy Finance

Table 3.6 Research pathways to improved cellulosic biofuels production

Objective	*Current status*	*Scientific questions*	*Technologies to be used*
Feedstock development			
Develop high yield, low maintenance, sustainable energy crops.	Most biomass feedstocks are unimproved plants. Modern breeding and molecular engineering methods should be able to greatly improve biomass yield, disease and drought resistance, and other desired traits.	*Which genes control the various aspects of polysaccharide composition and synthesis?* *Can useful modifications to cell- wall composition be made by modifying the activities of these genes?*	High-throughput functional genomics to identify functions of all carbohydrate-active proteins in representative plant species. Genes that confer drought resistance can be identified. Engineer plants to contain the nitrogen fixation genes to accept nitrogen-fixing symbionts.
Engineer crops to facilitate the breakdown of ligno-cellulose into simple sugars	The presence of large amounts of lignin greatly impedes the hydrolysis of polysaccharides. Removal of lignin requires energy intensive and harsh pretreatments such as steam explosion or hydrolysis with hot acid	Lignin is needed to confer structural integrity to plants. *Can the ratio and composition of various lignins be altered to produce robust plants that can easily be broken down so that most of the polysaccharides can be accessible to hydrolysis?*	Altering the ratios of guiacyl and syringyl lignin has been shown to greatly improve hydrolysis efficiency. Modification of existing lignins for improved plant deconstruction (e.g., lignin designed with cleavable linkages) should be possible.
Deconstruction			
Develop highly efficient feedstock pretreatment methods.	Current pretreatment methods, such as steam explosion, hot acid hydrolysis, thermo hydrolysis, are expensive and energy intensive.	*Are there less harsh pretreatment processes that can increase the surface area binding sites for enzymatic depolymerization and are more compatible with the enzymes or microbes to be used?*	Employ high throughput, micro-system testing of pretreatment combinations with lignin-modified transgenic plants. Use modeling of different physical and chemical processes to optimize the pretreatment method.
Identify more efficient enzymes for depolymerization.	The efficiency and cost of the enzymes is a major cost in the production of cellulose-based ethanol.	*Can we significantly improve the enzymatic activity with decreased product inhibition?*	Employ more systematic, high throughput searches for better enzymes. Improve newly discovered enzymes with mutagenesis and directed evolution methods.
Develop microbial communities for ligno-cellulose degradation.	Microbial communities and their role in biomass decomposition is poorly understood.	*Can self-sustaining microbial communities be used in lignocellulose deconstruction?*	There exist many unexplored microbial communities that can be screened for compost degradation, metagenomic sequencing, characterization, and cultivation. These microbial communities can serve as a new source of lignocellulolytic enzymes

TABLE CONTINUES ON NEXT PAGE

CONTINUED TABLE 3.6

Fuels synthesis			
Improve ethanol production.	Existing microorganisms are incompatible with current pretreaments.	*Can we develop fermentation organisms that can tolerate low pH or other processing conditions?*	Use genomics, metagenomics and synthetic biology to engineer tolerance to treatment conditions not found in nature.
	Current organisms are not compatible with high levels (greater than 15%) of ethanol production.	*Can we understand and improve an organism's tolerance to the fuels it produces?*	Apply systems and synthetic biology to engineer tolerance. Develop continuous fuel extraction methods to limit fuel concentration in the fermenting medium
Develop microorganisms to produce improved transportation fuels.	Ethanol production via fermentation is based on a 5,000-year old technology.	Butanol and heavier hydrocarbon (diesel-like) fuels have higher energy density and efficiency, and do not absorb or mix in water. *Can organisms be developed to produce these more desirable transportation fuels?*	A challenge of synthetic biology to create micro-organisms that can efficiently produce a heavier hydrocarbon transportation fuel that will self-separate from its aqueous environment.