World Challenges and Climate Change
The Role of Brazil

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Energy and Climate

World Challenges

Energy policy → deregulation → energy policy

- **1973 and 1979 oil shocks pointed out the need of energy policy and planning by the State to guarantee the supply at national level**

- **Second half of the 1980 decade → the fall of oil barrel price did push energy to free market**

- **Years 1990 → economy deregulation in many countries of Latin America**

- **Present days → return to energy policy in the World**

  economy crisis started in USA in 2008
  global warming

Key challenges in energy policy today

Variation of oil barrel price from US$ 10 in 1999 to US$ 70 in 2006 →up to US$ 140 in 2008 → US$ 100 today

Prospects of the limits of World oil reserves and production

Growth of energy consumption in developing countries, mainly in China in last years, and OECD dependence on oil importation

World geopolitical instability involving large oil producers

Environmental pressure and global warming by GHG emissions

The double face of economy crisis:

Lack of investments for alternative energy sources

State role could impose restriction on CO_2 emissions

Present Climate Change Issues

- According to IPCC Forth Assessment Report [2007], the world GHG emissions did grow up 70% from 1970 until 2004.

- Among them, CO_2 emissions have increased 80% and they were 77% of GHG anthropogenic emissions in 2004.

- So, CO_2 remains as the main GHG from anthropogenic sources.

Growth of GHG emissions from 1970 until 2005

- electric energy generation 145%,
- transportation 120%,
- industry 65%
- change of land uses and deforestation 40%.

Present Situation in the World

- Developed countries are not reducing their emissions in such a way to limit the global temperature growth in 2° C by the end of the century .

- Developing countries tend to increase their emission with the economy growth as they follow developed countries consumption pattern.

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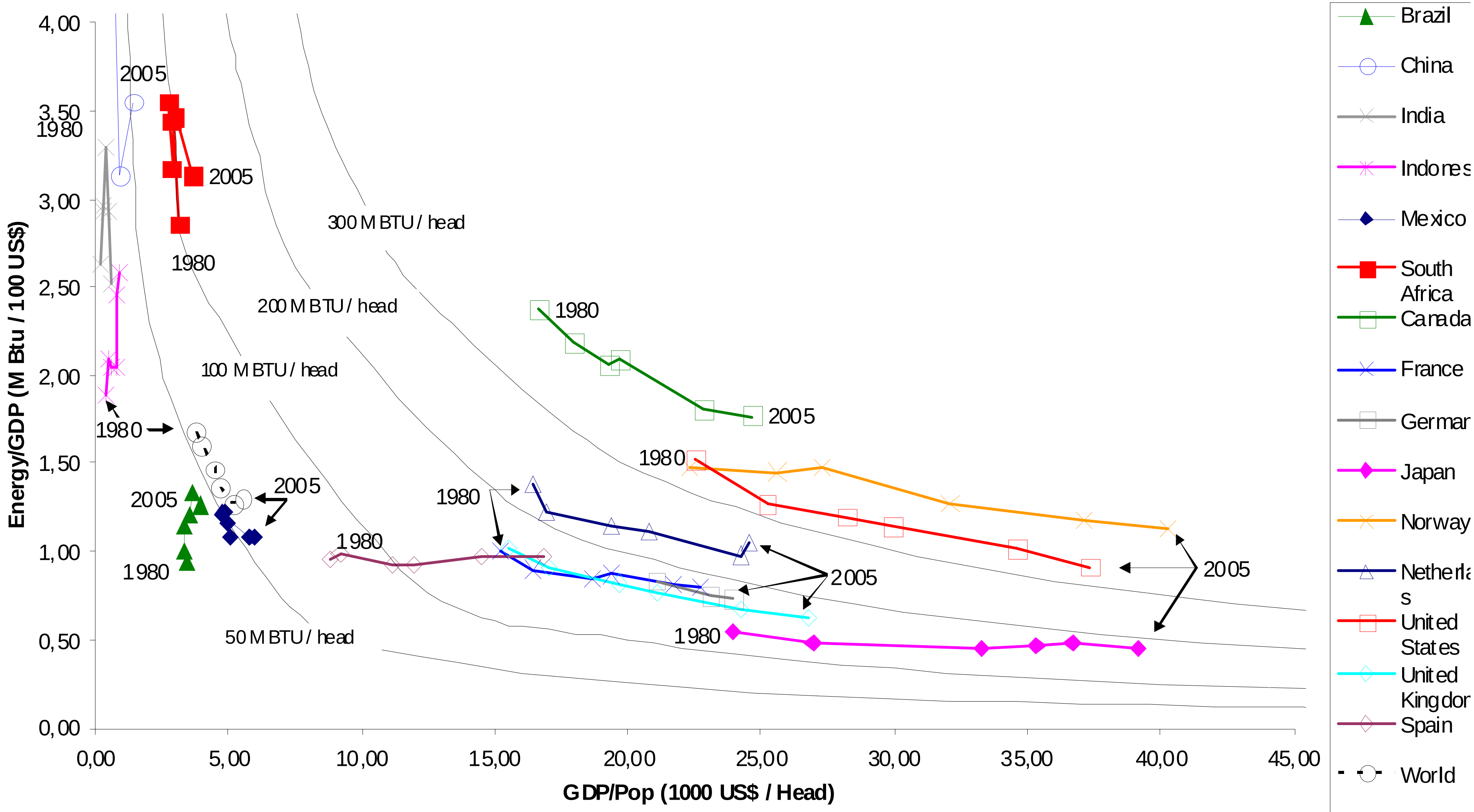
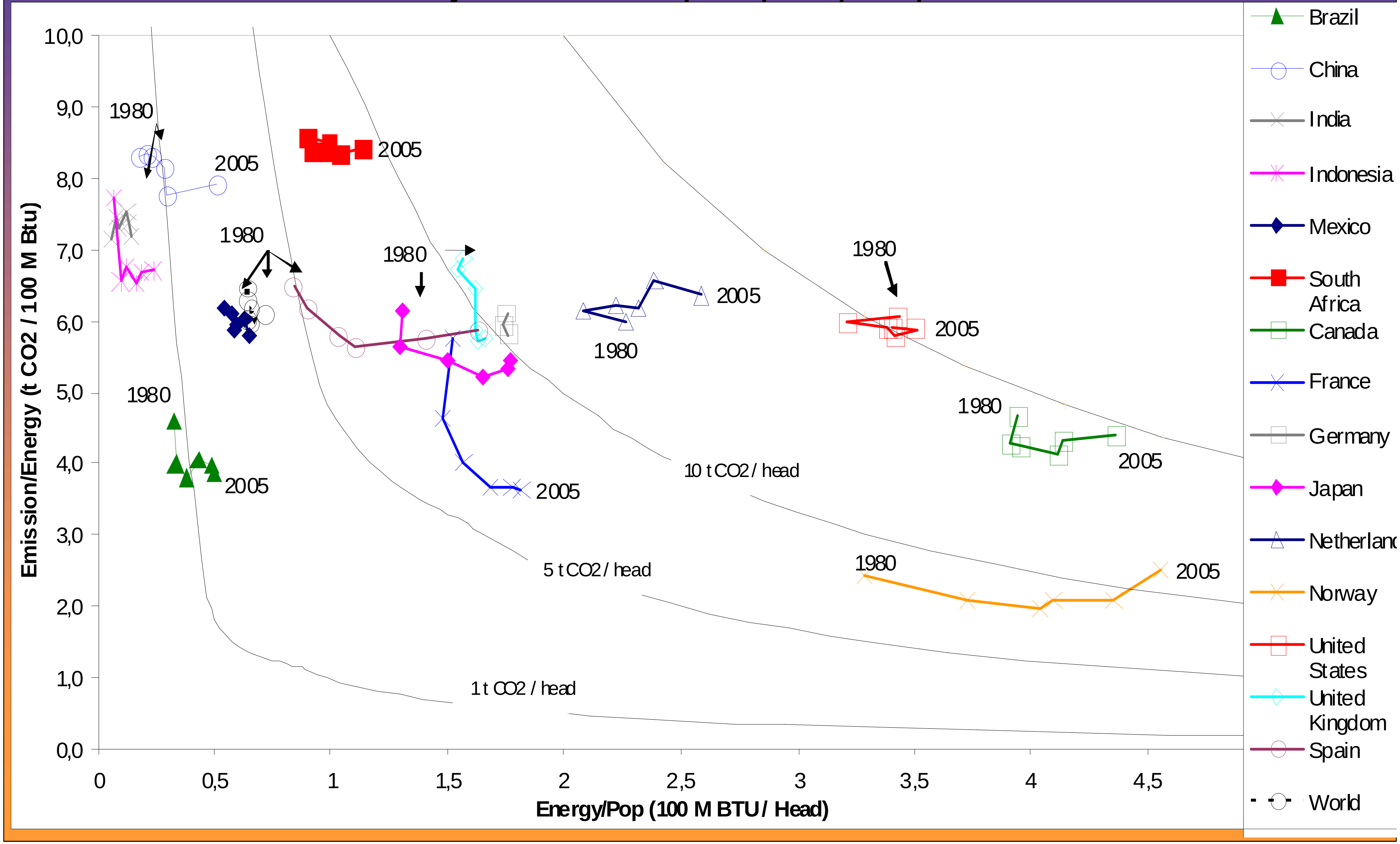
Energy per Capita (E / Pop = E / GDP x GDP / Pop)
Data from years 1980, 85, 90, 2000 and 2005



CO2 Emissions per Capita from Energy (CO2/Pop = E/Pop x CO2/E)

Data from years 1980, 85, 90, 85, 2000 and 2005



Present Situation in Developing Countries

- High income classes in developing countries have high energy consumption while the majority of population is poor and has very low energy consumption.

- So there is strong inequality of the energy consumption and of GHG emissions per capita inside each country following the inequality in income distribution.

Criticism and Proposal

- It is not to possible to avoid global warming without any change in business as usual energy consumption and deforestation, from which comes the biggest contribution of Brazil to GHG World emissions.

- It is necessary to pay more attention to technology development aside the scientific research on climate change.

- Climate Change Policy must be devoted to find realistic solution for:

  - changes in the intensive energy production and consumption pattern
  - protect population against effects of climate change.

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Present Situation and Challenges in Brazil

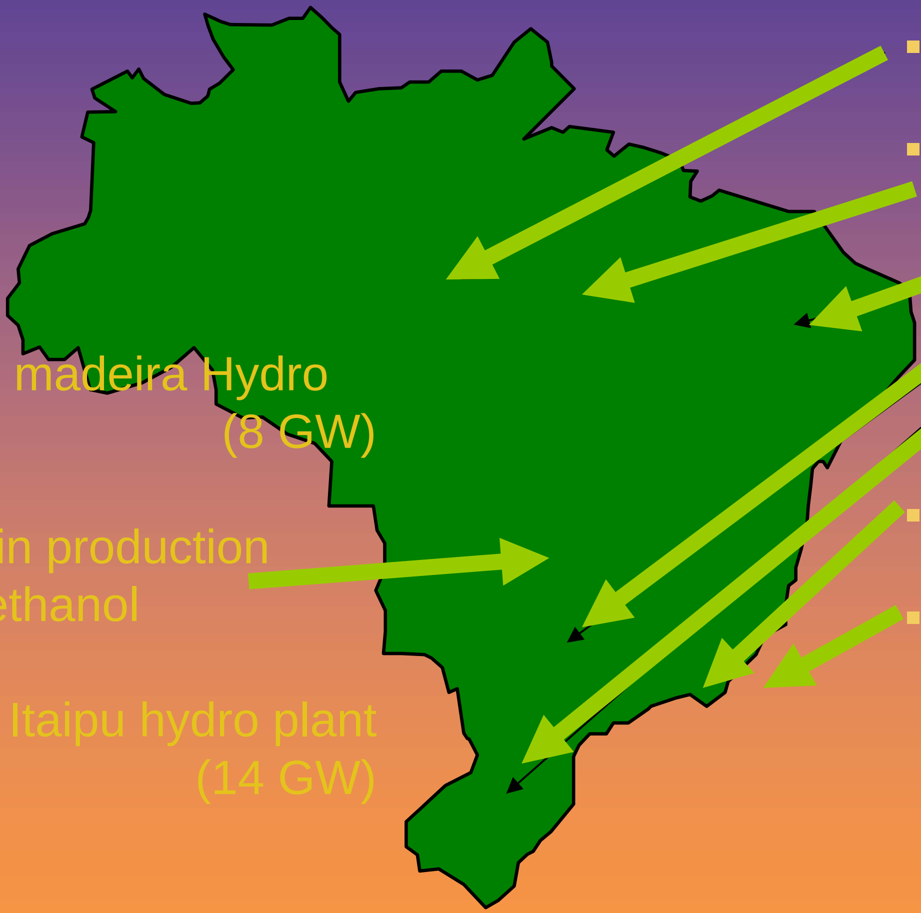
Present situation in Latin America

1 – Economic growth after more than a decade of very low development

2 – Very high social inequality

3 – The effects of economic crisis after 2009

Brazil



- Amazon rainforest and river in North Region
  - half of the Country area
- Tucurui Hydro (8 GW)

Northeast,
Southeast
South

Most populated areas

Rio madeira Hydro
(8 GW)

Main production
of ethanol

Itaipu hydro plant
(14 GW)

- Most industrialized → Southeast
- Oil off shore production
- More than 20 millions of Brazilians did improve their social condition coming out from poverty to market economy after 2003

Important Economic Activities

- Off shore oil technology, self sufficiency in oil production (about 2Mb/d)

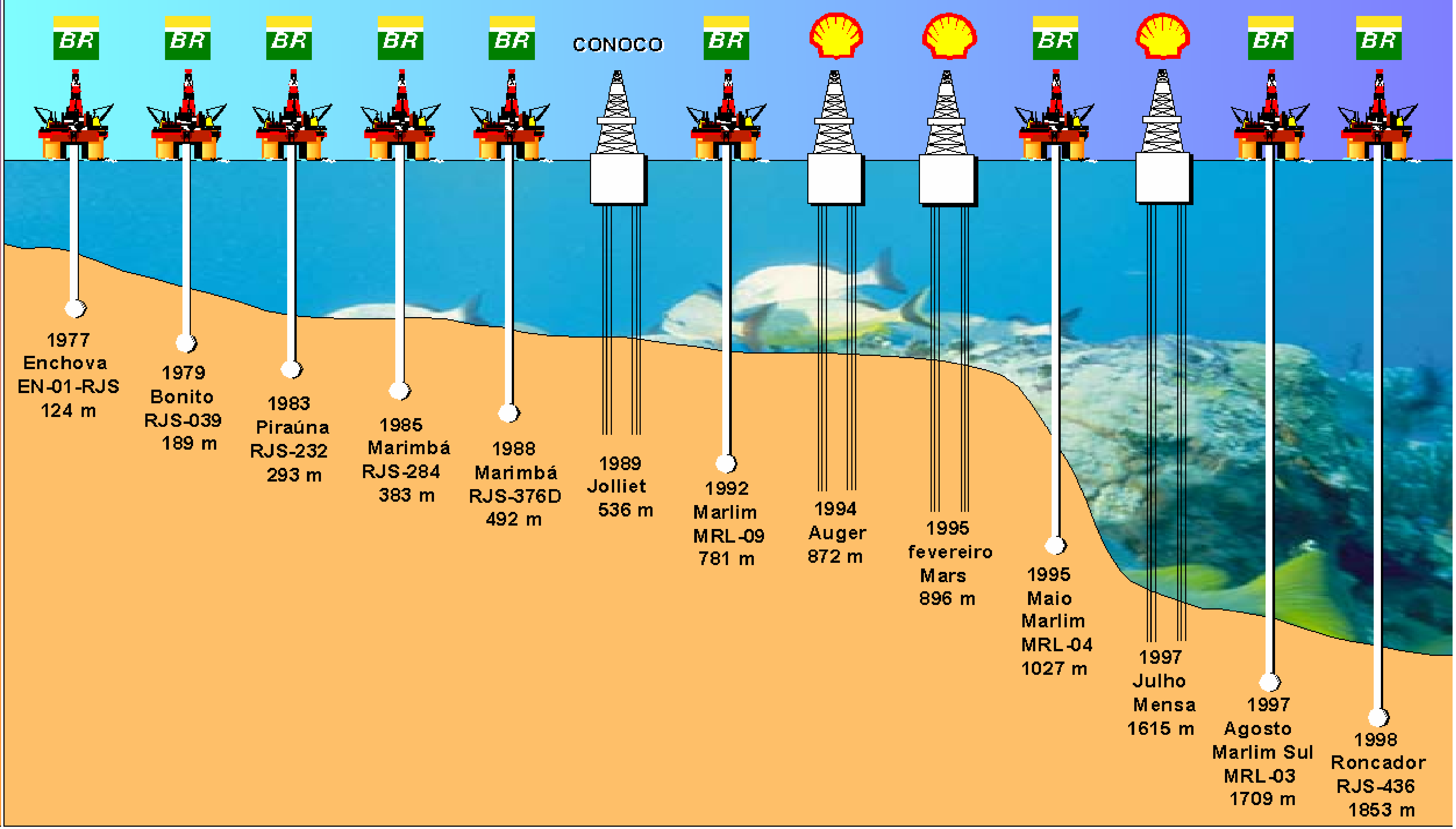
Recent discovery of oil in deep water → Pré-sal

Largest producer of ethanol from sugar cane

Large hydropower interconnected system →more than 80% of electric power

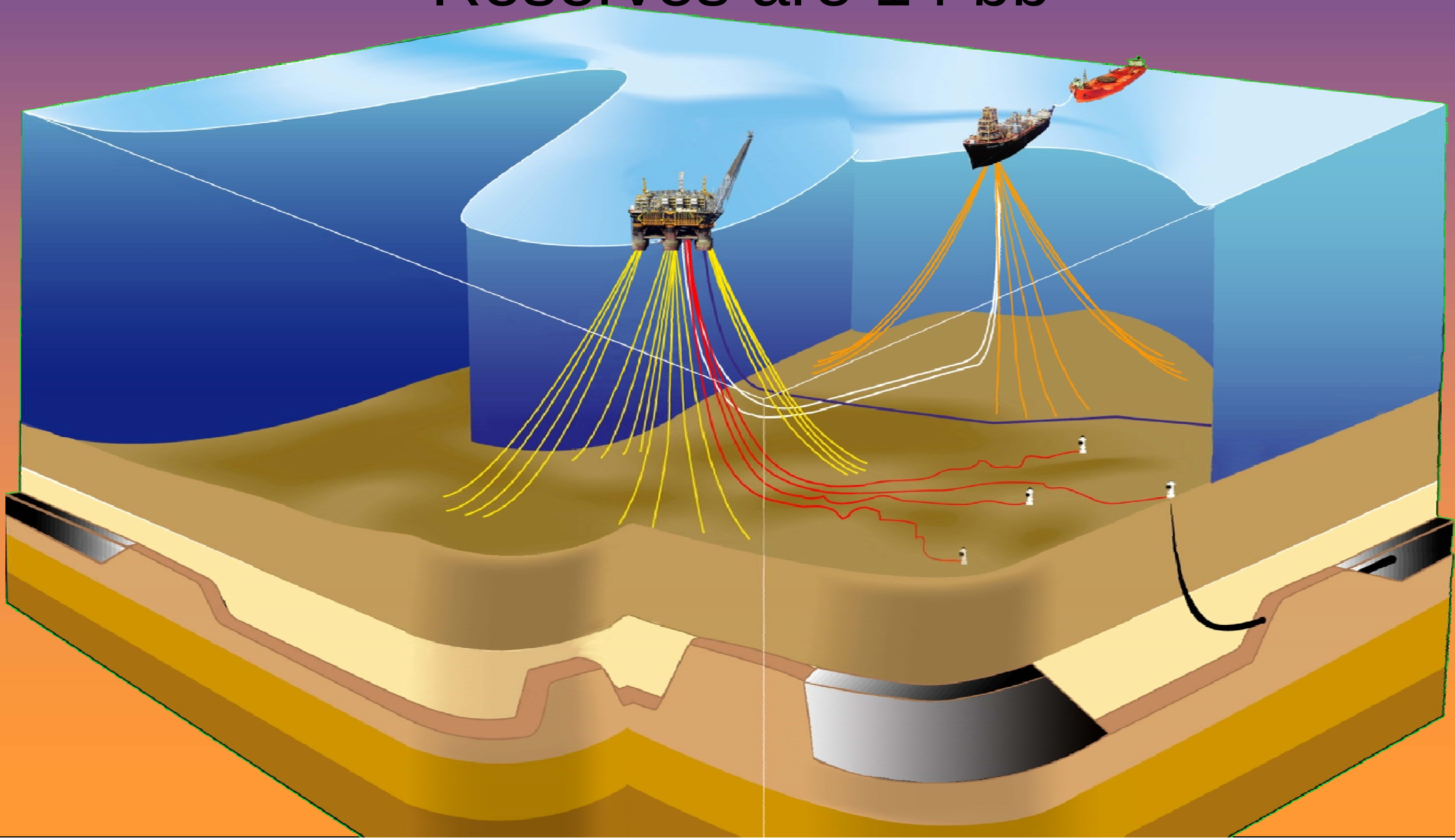
PETROBRAS Records in Off Shore Oil Technology

Recordes Mundiais de Produção em Águas Profundas



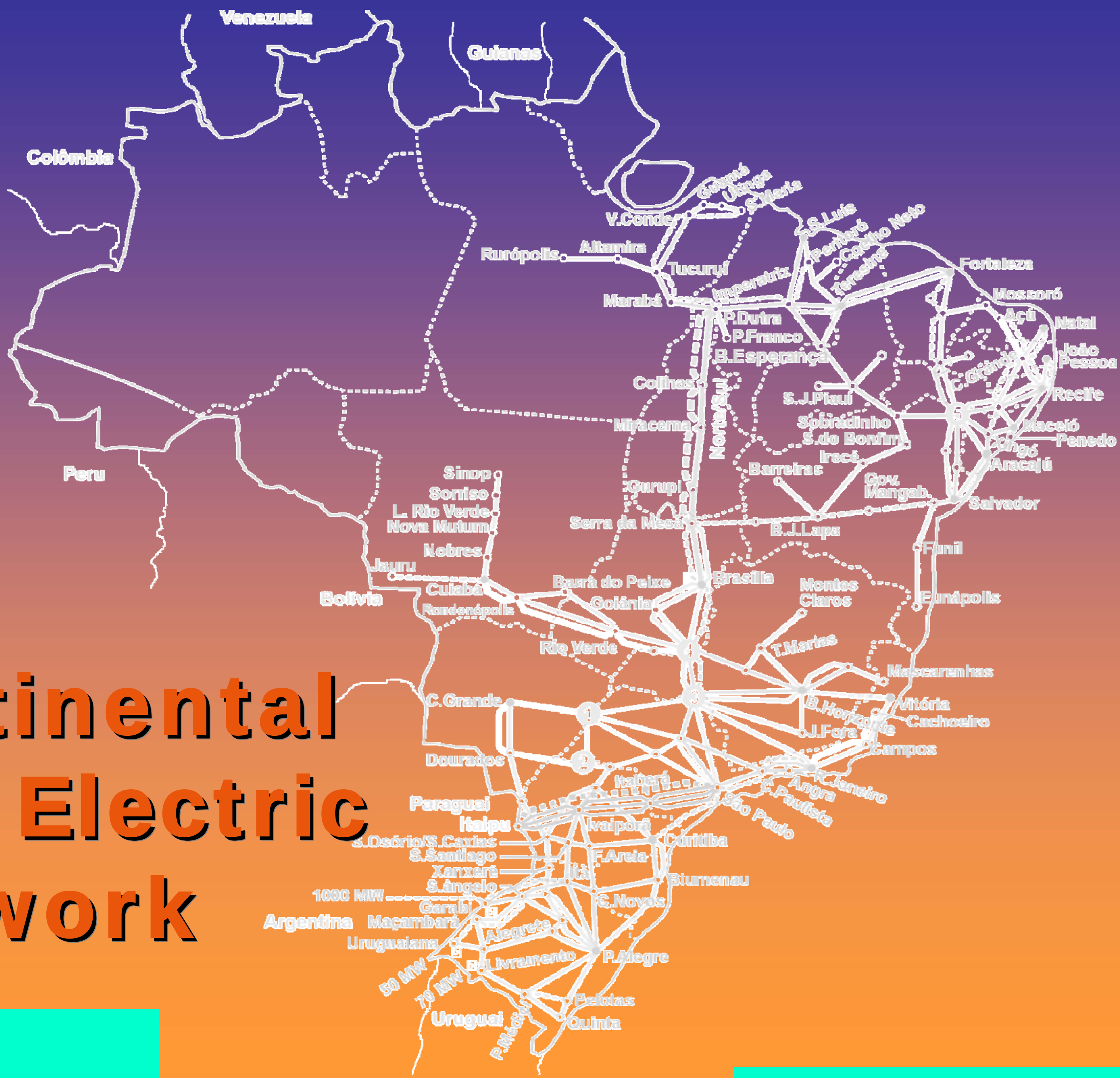
Offshore Oil Reserves in Brazil at Very Deep Water (Pré-Sal)

From 30 t0 80 bb while present Brazilian Oil Reserves are 14 bb

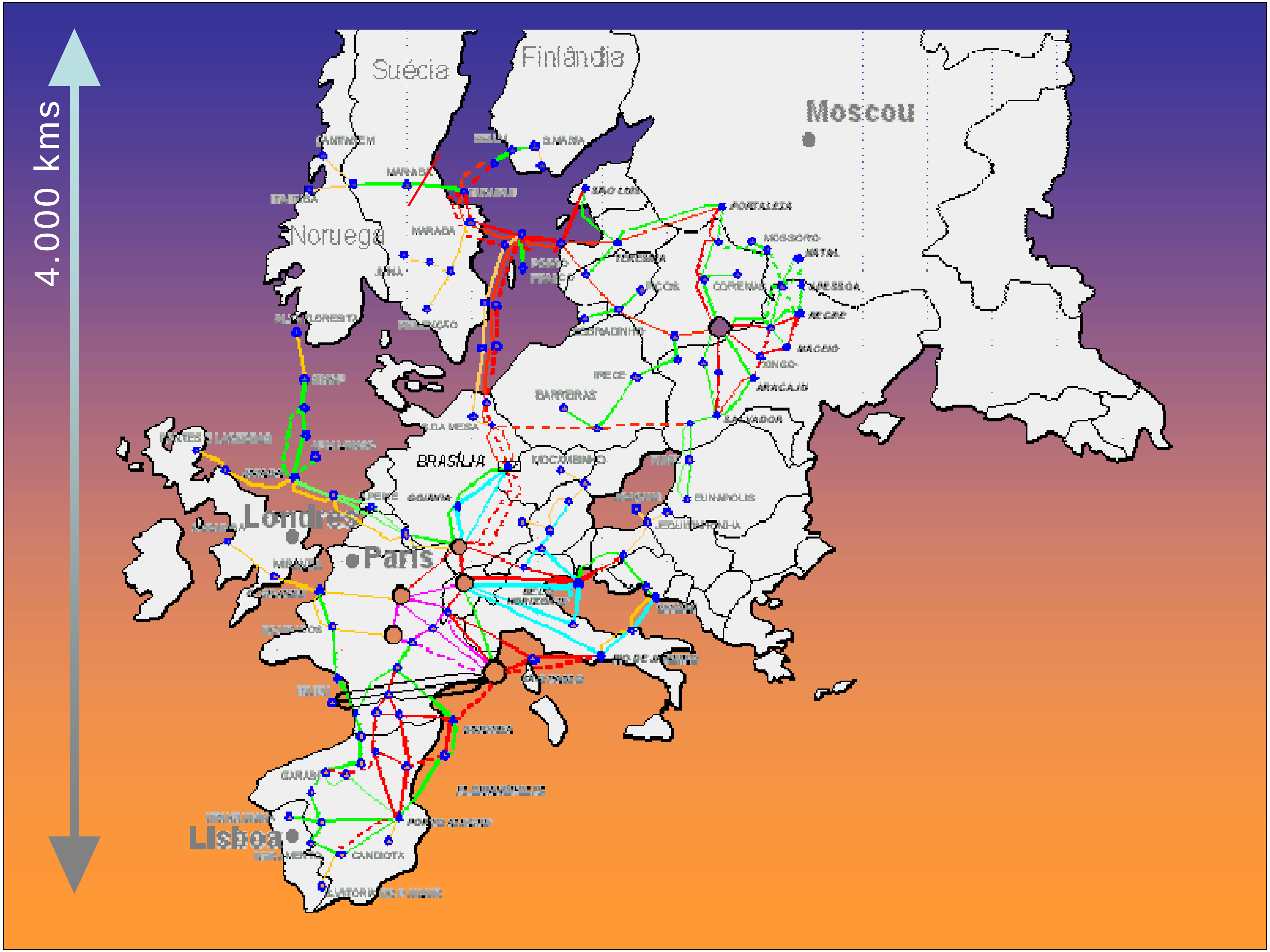


4.000 kms

A Continental Size Electric Network



SOURSE: ONS – 2002 / ILUMINA



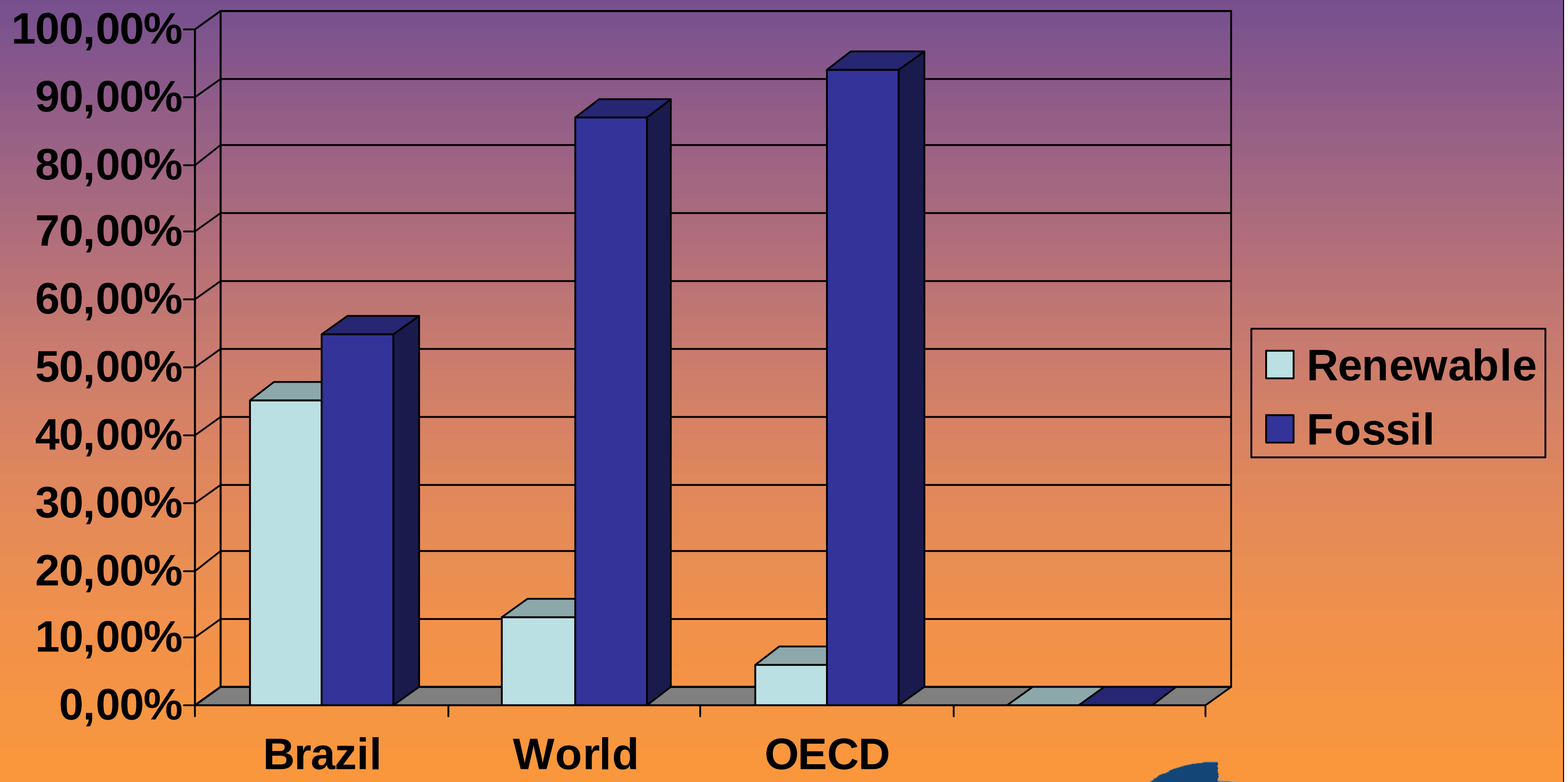
4.000 kms
Suécia
Finlândia
Moscou
Noruega
Londres
Paris
Lisboa
BRASÍLIA
BARREIRAS
IRECE
GOIANIA
EUNAPOLIS
JEQUITINHONHA
FORTALEZA
NATAL
RECIFE
MACEIO
ARACAJU
SALVADOR
CANDIOTA

Electric Exclusion

- 12 millions of persons did not have electricity in 2003
- 88% of them are in rural areas
- 59% are in the North
- In the North there is not electric grid → isolated system using dieses oil with subsides of about US$ 2 billions in 2006 → alternatve sources of energy potential

Light for All Program

Renewable and Fossil Energy %



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Hydroelectric Power

Table 1 – Top ten countries with largest water resources

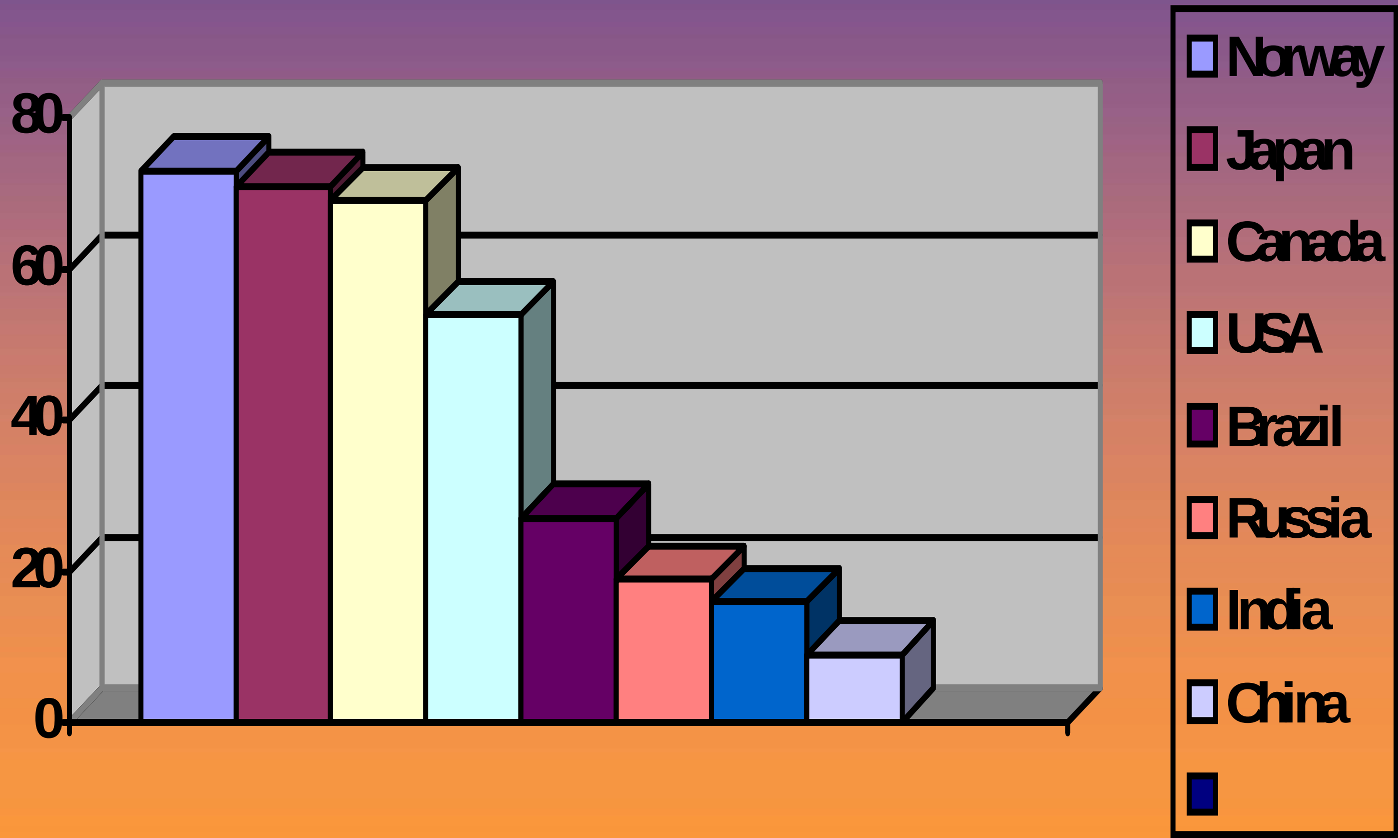
	Thousands Km^3/year	M^3/year/inhabitant*
Brazil	8.2	48.3
Russia	4.5	30.9
Canada	2.9	94.3
Indonesia	2.8	13.3
China	2.8	2.2
USA	2.0	7.4
Peru	1.9	74.5
India	1.9	1.8
Congo	1.3	25.1
Venezuela	1.2	51.0

Source: D'Áraujo 2008; FAO 2003; *per capita data is for 2001

Countries with higher hydro capacity 2005 data

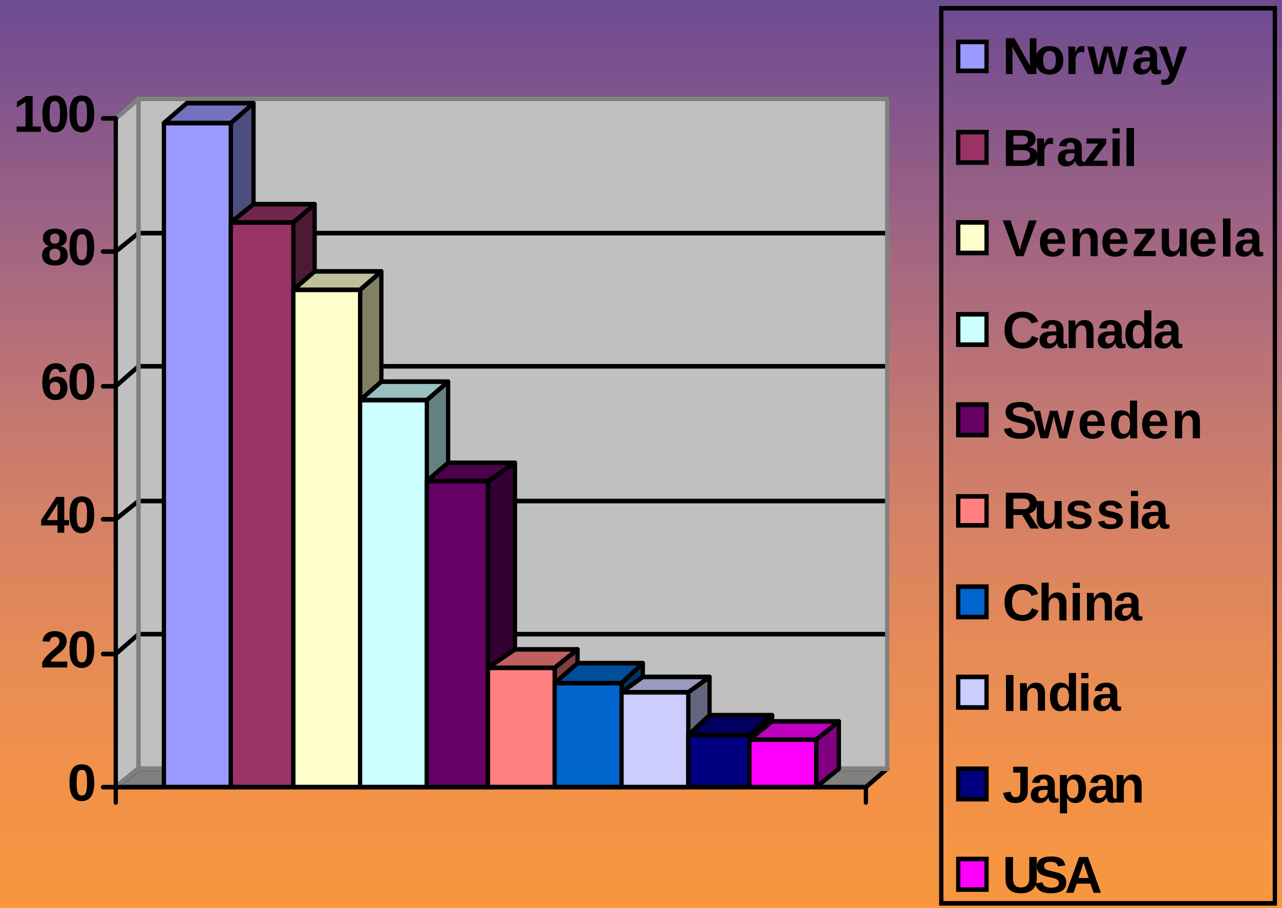
	Installed Capacity (MW)
China	100.000
USA	77.354
Canada	71.978
Brazil	71.060

Percentage of economic hydropower potential that is currently utilized in selected countries



Source: WEC 2007; BEN 2007 for Brazil estimate

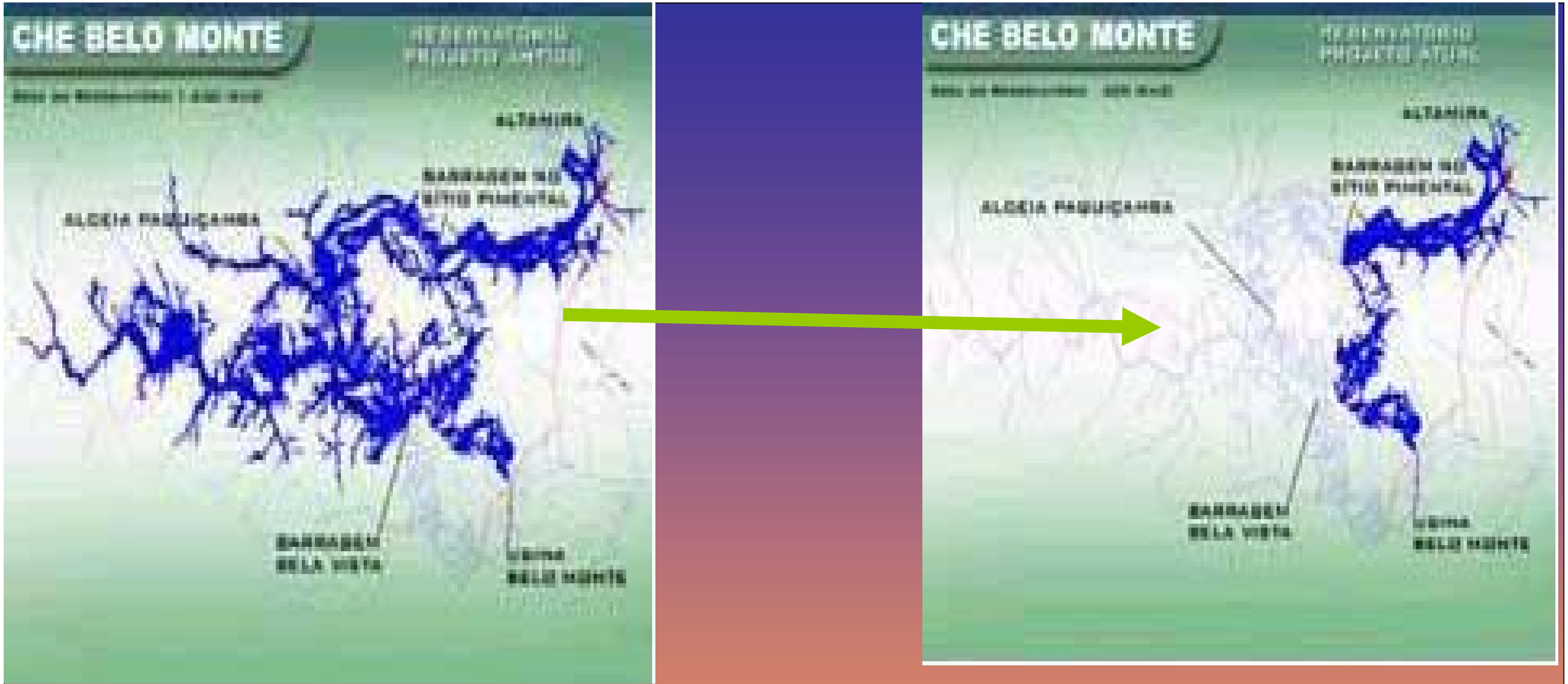
countries with the highest percentage of hydropower in their electricity generation (%)



Source: IEA, 2006

Problems of hydroelectricity in Brazil

- Environmental questions
- Movements against dams
- Pressure to abandon hydroelectricity expansion
- Thermoelectric power plants / hydropower



Belo Monte Hydroelectric Power Plant

(Start construction this year)

Reduction of Reservoir Area → Flow of River

Biofuels

TECHNOLOGICAL ALTERNATIVES FOR BIOMASS

Technical Process:		Biomass:	Products:
Direct Combustion		Firewood	
		Wastes (Bagasse)	
Bioconversion	Fermentation:	Sugar Cane	Ethanol
		Corn, etc	
	Anaerobic digestion:	Wastes	Biogas
Chemical / Thermal Conversion	Pirolisys:	Wood	Charcoal
	Gaseification:	Biomass	Gas of Sinthesys
	Esterification:	Veget. Oils	Biodiesel
		others	
	Cracking Hydrogenation:	Veget. Oils	Diesel
	Hydrolisis	Biomass	Ethanol

Ethanol in Brazil

- Successful program of sugar cane ethanol in substitution for gasoline.
- Advantage of burning sugar cane bagasse in the distillation process of ethanol, avoiding net greenhouse gas emission.
- In the US and EU production of ethanol from corn, fossil fuel is used in the distillation process emitting GHG.

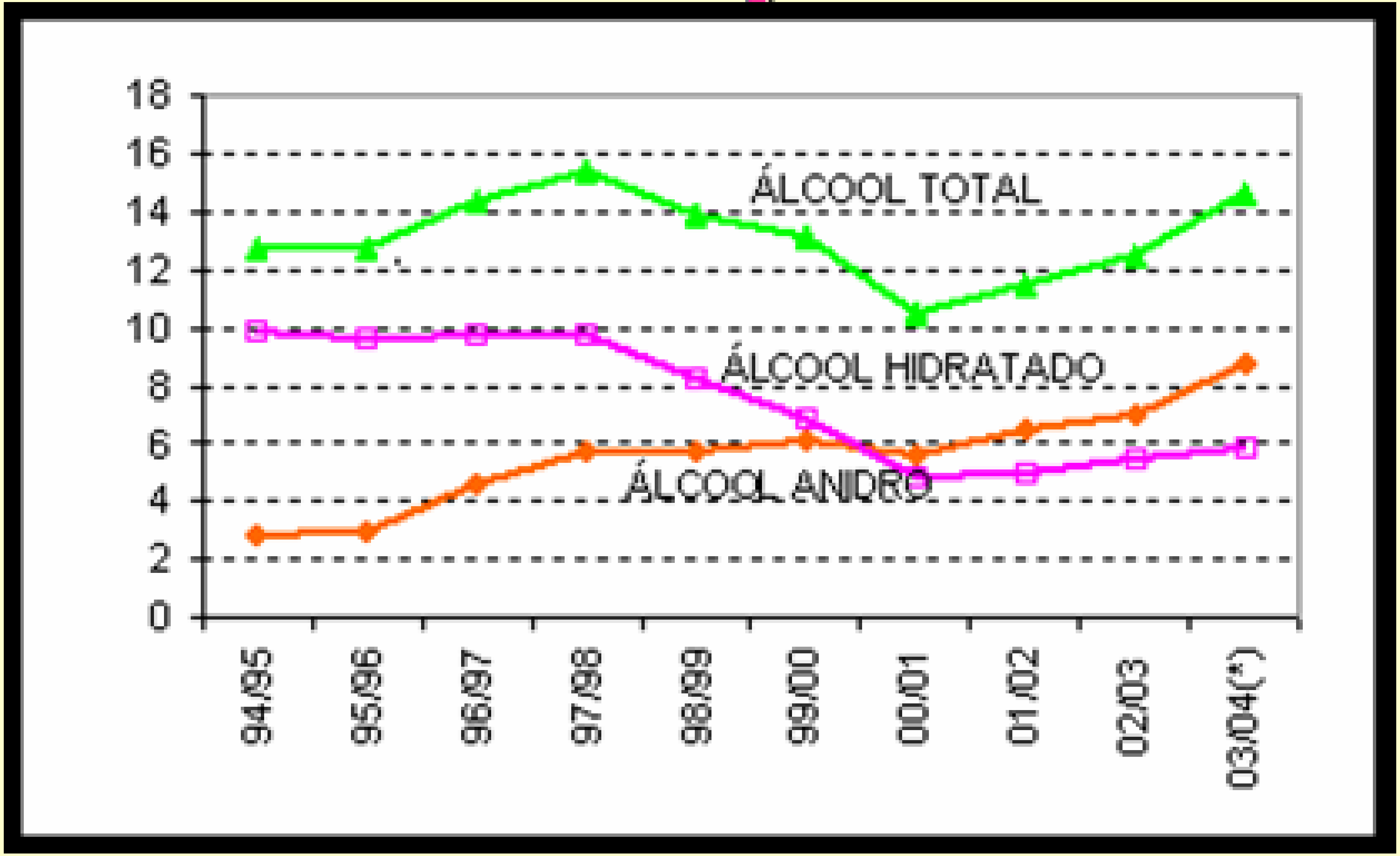
1 GJ of fossil fuel → 1,3 GJ of ethanol from corn
1 GJ of fossil fuel → 8 GJ of ethanol from sugar cane.

corn ethanol → avoides about 20% of GHG from gasoline emission
sugar cane ethanol → avoides 85% of GHG from gasoline emission

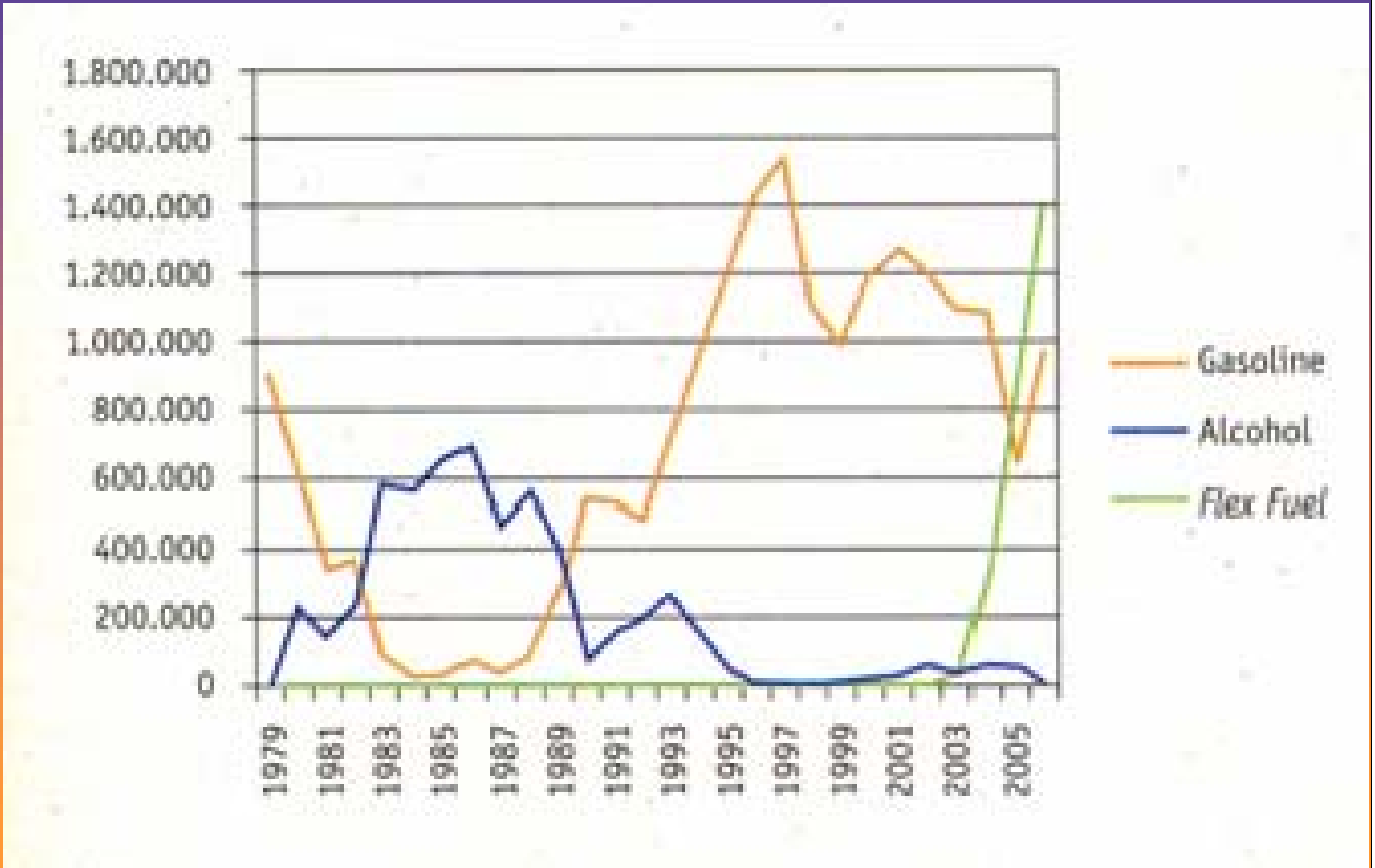
Ethanol consumption in Brazil

1 –Total; 2 – As additive to gasoline

3 - Pure ethanol engines and flex cars

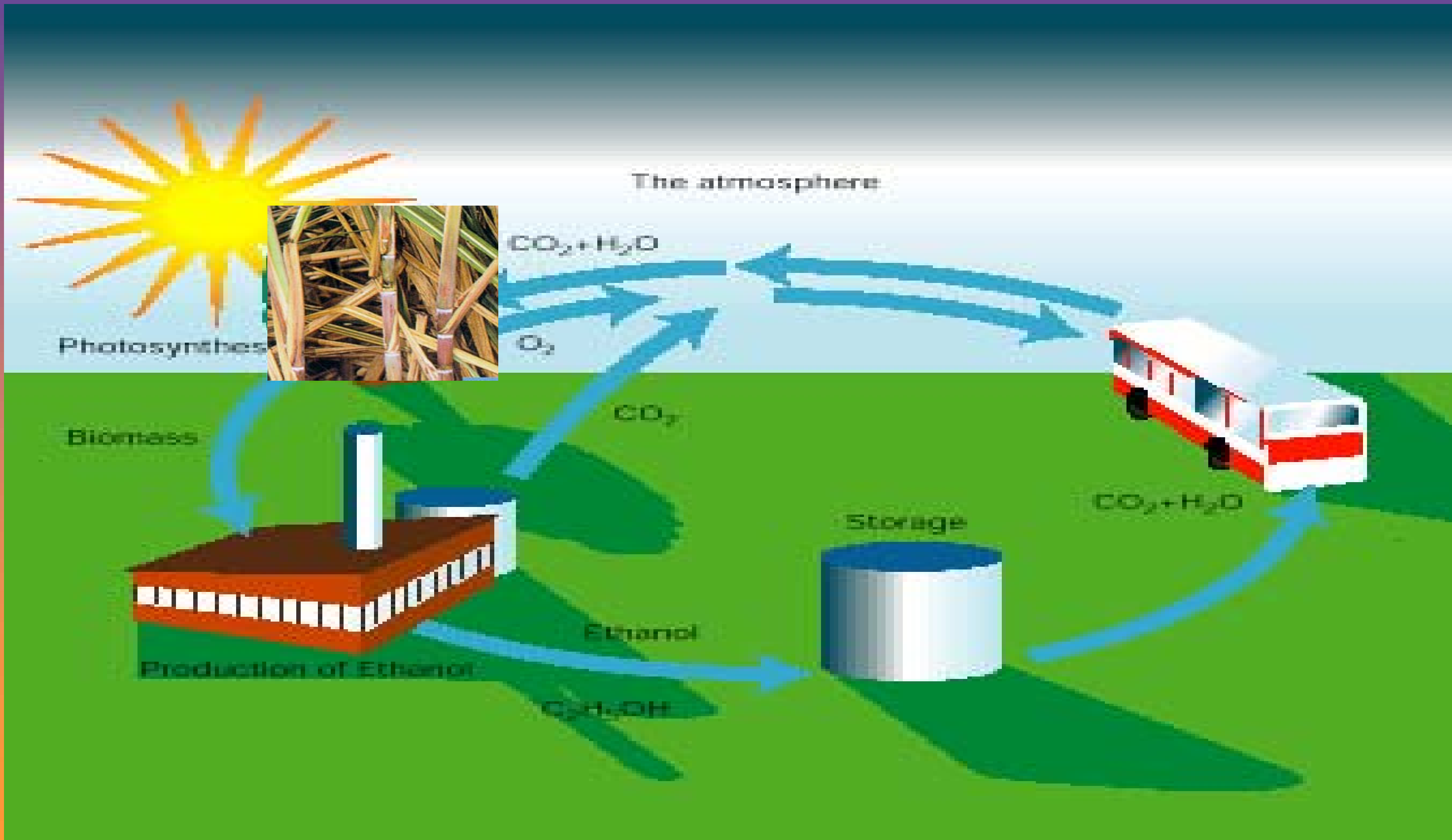


Sales of Gasoline, Alcohol and Flex Cars in Brazil



Sugar Cane – Carbon Cycle

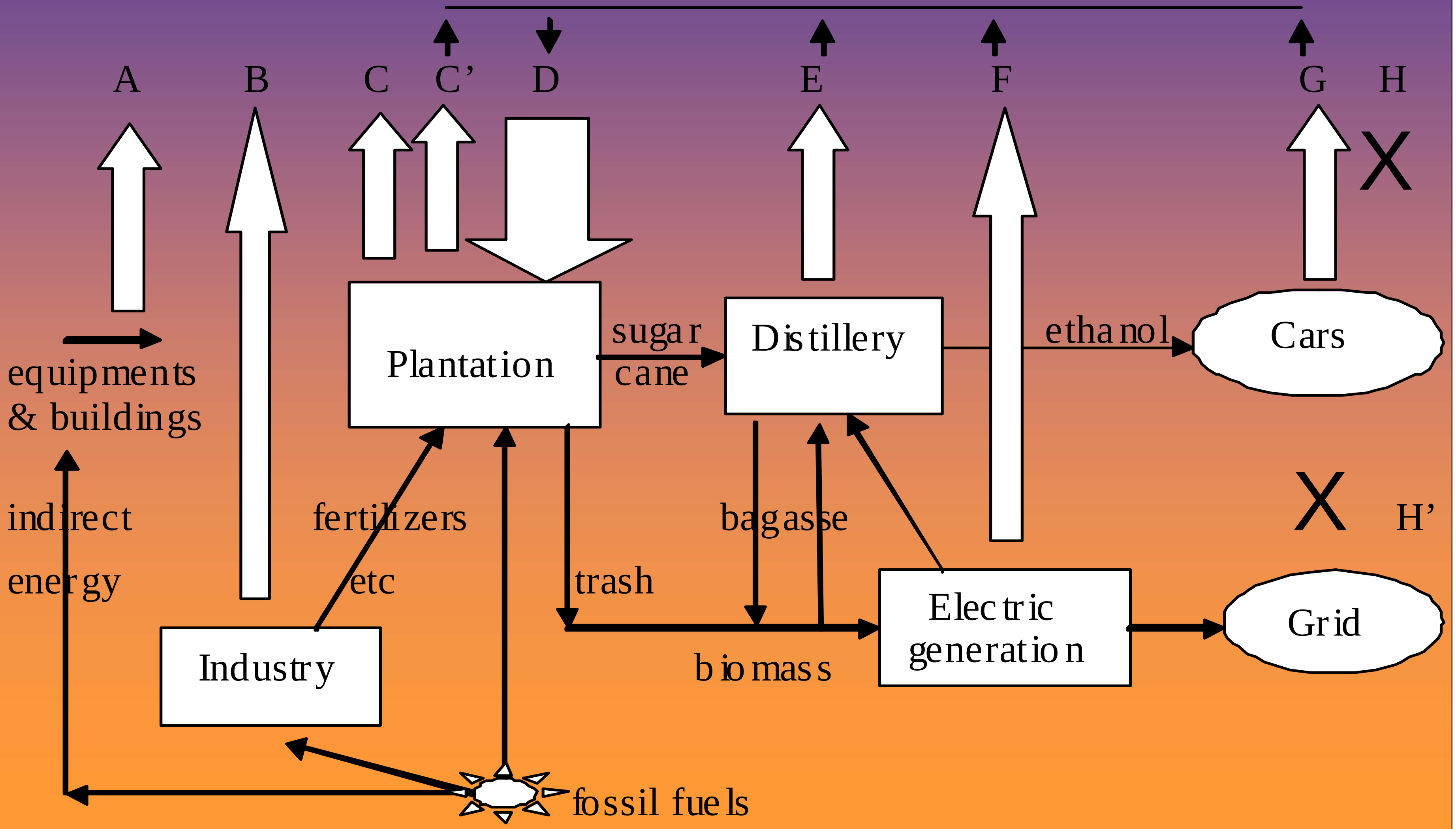
Ref: Suzana K. Ribeiro, COPPE, 2006



GHG missions in sugar cane ethanol production and avoided CO2

Balance of CO2 capture by sugar cane: D = C'+ E + F + G (3)

Net avoided CO2 by sugar cane ethanol = H + H' – A – B - C (4)



Net avoided CO_2 in terms of percentage of fossil fuel CO_2 emission:

Sugar cane ethanol

$$P = 1 - (A + B + C) / (H + H') \qquad (6)$$

Corn ethanol

$$P = 1 - (A + B + C + E + F) / H \qquad (7)$$

Sugar cane ethanol relative to gasoline

$$P' = 1 - (A + B + C - H') / H \qquad (8)$$

BIODIESEL

FINAL USE OF BIODIESEL:

PURE

B(100)

MIX

B(2), B(5), B(20)...

ELECTRIC ENERGY

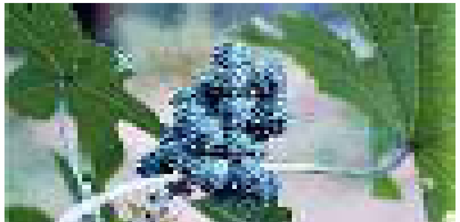
TRANSPORT

INPUTS

Biodiesel Program intends to stimulate family

Main raw materials for the ester production

- **Vegetable oils**

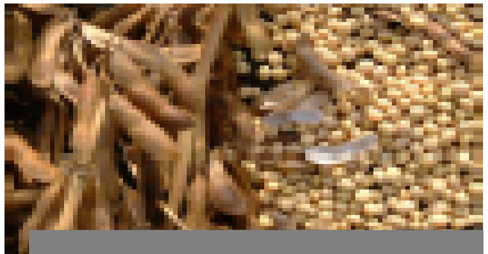


Castor oil plant

Colza

Palm

Sunflower



Soy

The issue of land use for biofuels and competittion with food in Brazil:

- **Present sugar cane production – 7 millions ha**
about half for sugar , so for ethanol - 4 millions ha

- **For comparison : Soy bean – 23 millions ha**

The Country has:

440 Mha of forest

177 Mha of pastures for cattle

152 Mha for agriculture, while → 4/152 = 2.6%

62 Mha are used for agriculture,

90 Mha to expand agriculture without deforestation

-No problem for internal market:

fuel consumption of cars = ½ gasoline + ½ ethanol

it is possible to double ethanol production without big problem

Present sugar cane plantations are not in North were there is the Amazon forest.

The Energy Potential of Sugar Cane

Energy from 1 Metric Ton of Sugar Cane

Considering Heat Values

	Mcal/t of cane
92 litters of ethanol (best value)	478
280 kg of bagasse with 50% of humidity	596
280 kg of trash with 50% of humidity	596

Source: Braunbeck, Macedo and Cortez in [Silveira, 2005]

The main changes in ethanol industry must be:

a) Improvement of efficiency in the transformation of chemical energy of sugar cane bagasse in heat for distillation and for electric energy, to self consumption and to the grid.

b) Participation of bagasse in the electric generation is too small and must increase.

c) Utilization of sugar cane trash, burned before harvesting to allow the manual job of workers; the amount of energy that could be obtained for electric power is high.

d) Item (c) implies the increase of harvesting mechanization, decreasing the number of workers, but job conditions in manual harvesting is hard.

e) Technological improvement:

gasification of bagasse and trash;

hydrolisis of bagasse and trash → cooperation with Japan

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Mudanças Climáticas

Brazilian Plan of Action on Climate Change

Brazilian Commitment in 15th COP at Copenhagen – December, 2009

- **On 13th November 2009 President Lula announced that Brazil should cut betwewen 36.1% and 38.9% of estimeted emissions in 2020.**
- **The president presented this commitment in Copenhagen Conference.**
- **This voluntary goal (as Brazil does not belong to Annex I of Climate Convention) means a reduction of 1 billion tons of CO2.**

Elements of the National Plan on Climate Change presented at Poznam

- Actions involving several ministries under coordination of Ministry of Environment for **mitigation and adaptation**

- The first point is to **establish targets for reducing deforestation** → based on the facts:

  a) **most of the GHG Brazilian emissions did come from deforestation**;

  b) it has been reduced in Amazon in 2005, 2006 and 2007

- Creation of a **research network on climate change**

Fórum Brasileiro de Mudanças Climáticas

Brazil's National Plan of Action on Climate Change Main Points	China's National Climate Change Programme Main Challenges
1. Stimulate efficiency increase for better practices in the economy	1. Critical challenge to current development pattern
2. Keep the high share of renewable energy in the electric matrix	2. *Huge challenge to coal dominate energy matrix*
3. Increase in the share of biofuels in transport	3. Great challenge to independent innovation
4. *Reduction of deforestation rates to reach zero illegal deforestation*	4. Conservation and development of forest and other natural resorces
5. Eliminate the net loss of forest coverage in Brazil by 2015,	5. Adaptation to climate change in agriculture
6. Strength actions for reduction of the vulnerabilities of populations.	6 . Adaptation in water resources
7. Identification of environmental impacts resulting from climate change and stimulates scientific research for country's adaptation	7 .Adaptation in coastal regions

Research and Development at COPPE

COPPE is localized in Fundão Island

Campus of Federal University of Rio de Janeiro

Academic Excellence

- 320 full-time professors
- 3,000 students

- COPPE became a model for other universities and research institutes in Brazil.

COPPE D. Sc. and M. Sc. Courses

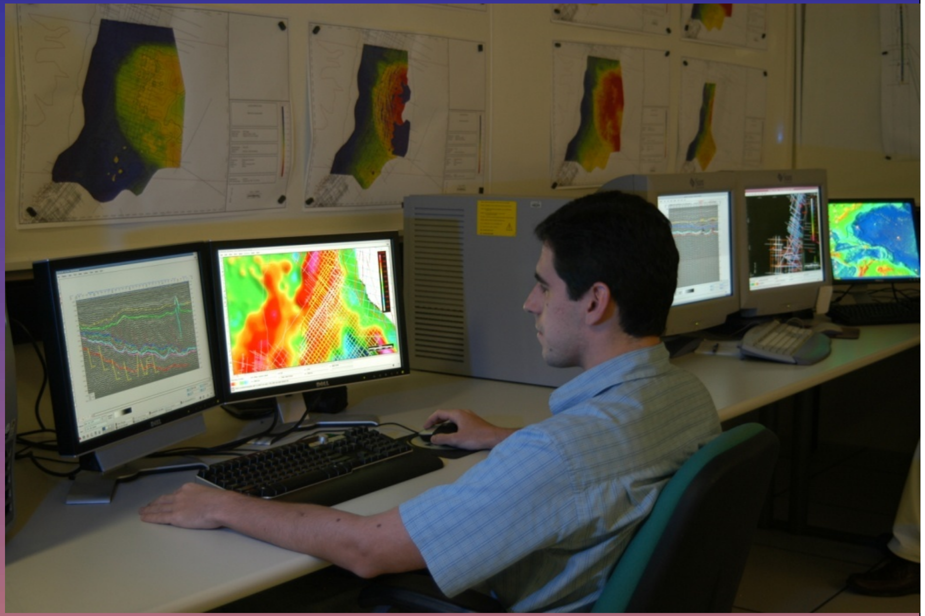
Courses

12 graduate programs for master's and doctor's degrees

- Biomedical Engineering
- Civil Engineering
- Electrical Engineering
- Mechanical Engineering
- Metallurgical and Materials Engineering
- Nuclear Engineering
- Ocean Engineering
- Energy Planning
- Production Engineering
- Chemical Engineering
- Systems Engineering and Computer Science
- Transportation Engineering

Research and Development in Conventional Energy and Environment I

Offshore oil monitoring

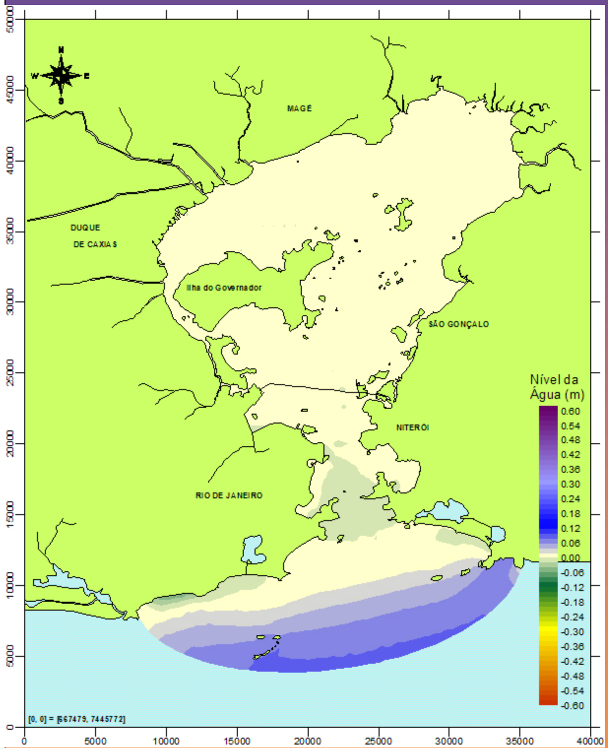


Satellite images and high performance computing to detect oil on the sea.
In partnership with the Petrobras Research Center and Mexican Oil Company, Pemex.

This technique has been successfully applied in the Baía de Campeche, in the Gulf of Mexico (Cantarell field → nearly 1,9 million barrels/ day).

IMPORTANT WITH THE ACCIENT IN OFFSHORE OIL PRODUCTION AT THE GULF OF MEXICO

Environmental Modeling System for Water Resources

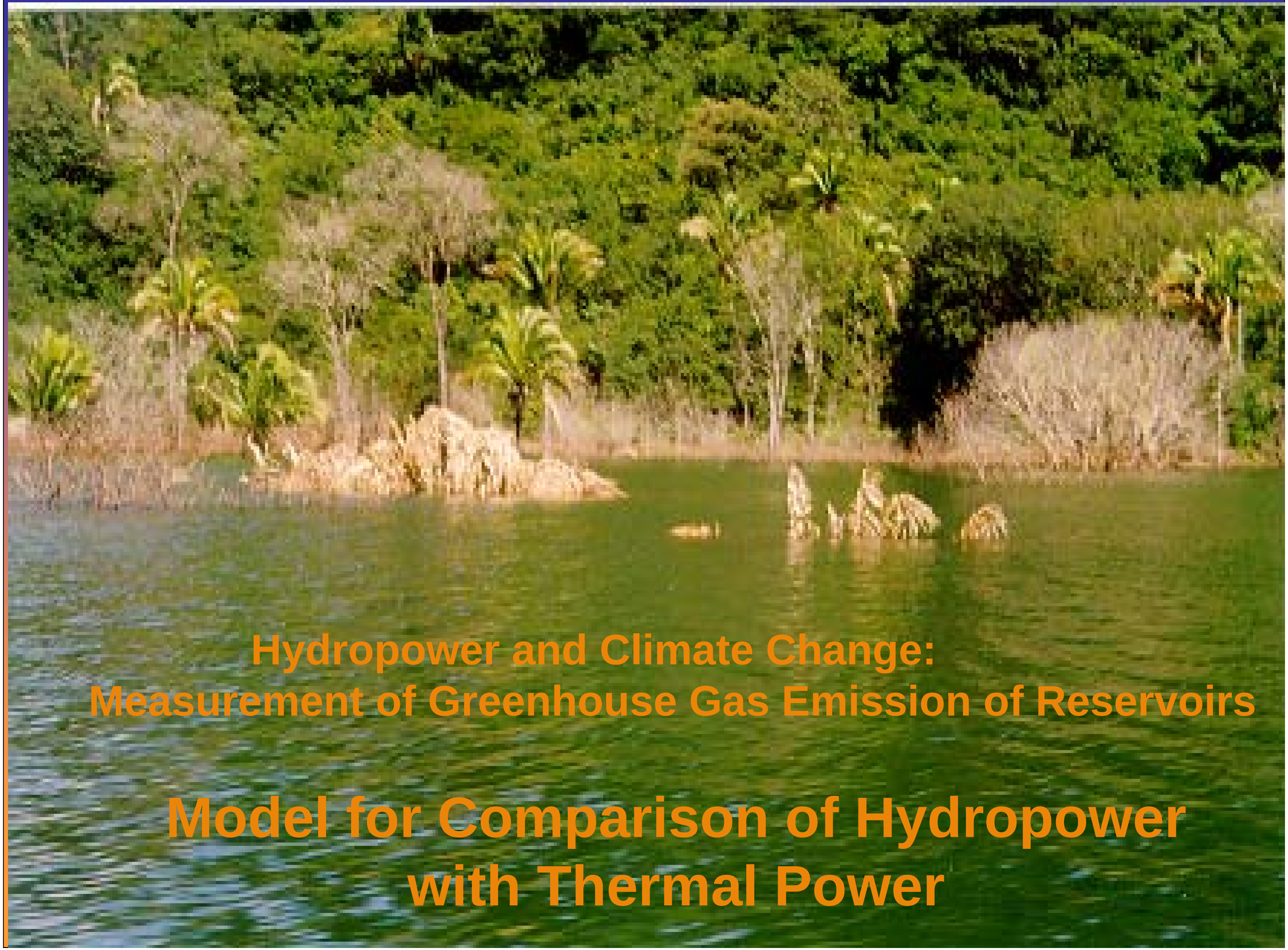


COPPE has developed a powerful instrument for emergency action planning in cases of the leakage of oil or other contaminants in rivers, reservoirs, lakes, estuaries and coastal waters.

A computational modeling system is used to simulate hydrodynamic circulation, dispersion of substances and quality of water in bodies of water with free surfaces.

The system aims to assure the environmental preservation of threatened areas and it has been successfully tested in Brazil sponsored by the World Bank.

Research and Development in Technology and Climate Change



Hydropower and Climate Change: Measurement of Greenhouse Gas Emission of Reservoirs

Model for Comparison of Hydropower with Thermal Power

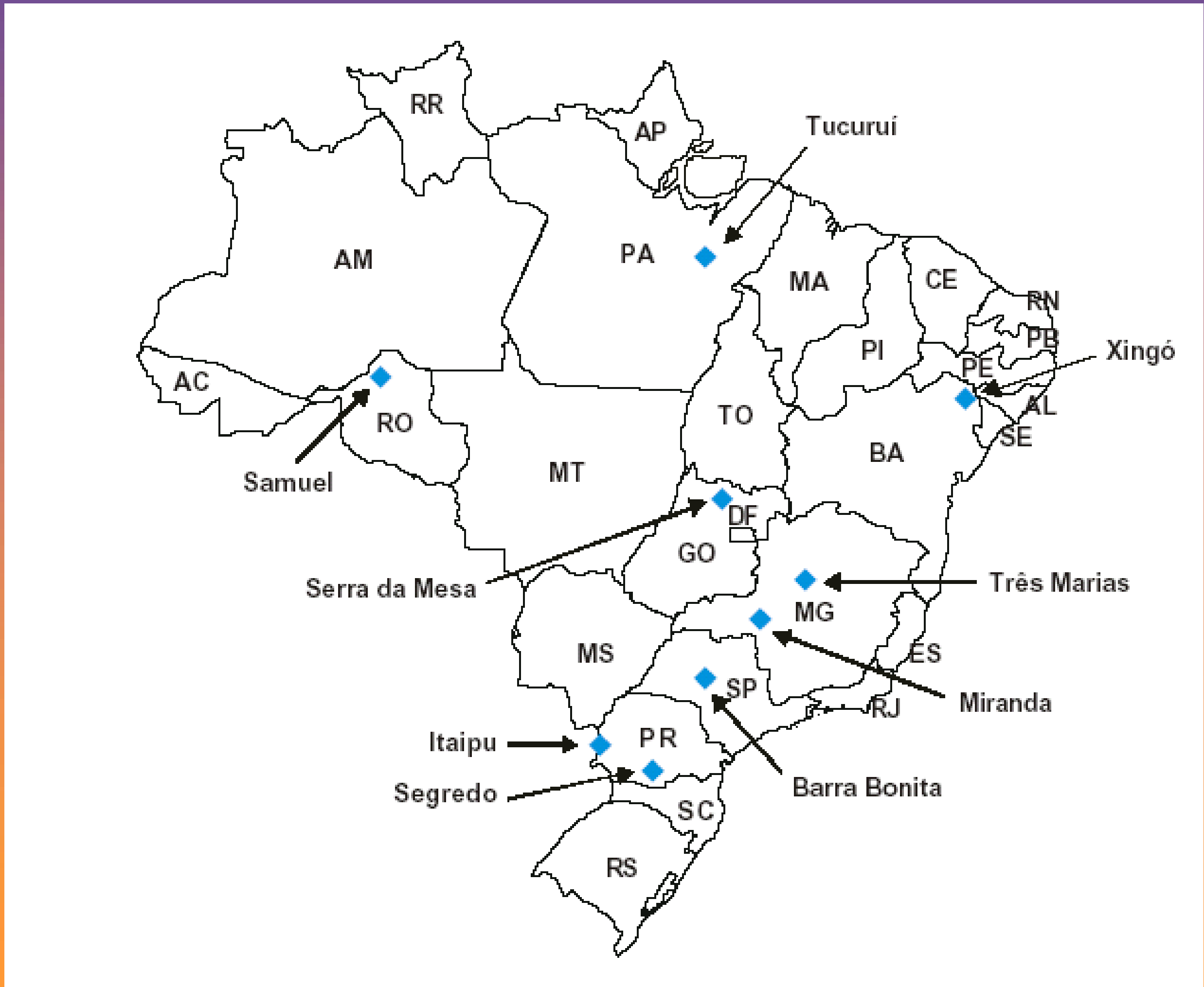
Emissions from Reservoirs: Instituto Virtual (IVIG) - COPPE

Funnel Bubble Collector Coupled to a Gas Collecting Bottle

COPPE / UFRJ

Group of Collecting Funnels Placed in a Shallow Region

Hydroelectric Plants GHG Emission – COPPE / IVIG



State of the Knowledge

Emission of CH_4 from hydroelectric reservoirs is always unfavorable to reservoirs.

Emissions of CO_2 can be attributed in part to the natural carbon cycle between the atmosphere and the water of the reservoir

.

There are three processes of GHG emissions:

- diffusive emissions,
- bubble emissions
- degassing and down stream emissions.

Most measured emissions in the World are of diffusive emissions only.

In tropical reservoirs of Brazil there are also measurement of bubble emissions and some initial studies on degassing.

Guide lines of IPCC (2006) pays attention to CH_4 emissions

Main Results:

Among the 10 reservoirs studied,7 of them, (with 97% of total installed capacity), have GHG emissions per MWh lower than those from natural gas power plants, some of them more than 100 times lower

The hydro-power plants with emissions per MWh higher than those of natural gas fuelled power plants have very low power density (less than 0.4 W/m2) and they totalize only 3% of total installed capacity.

.

Ecological Concrete

COPPE developed a new kind of concrete that reduces carbon dioxide emissions from the cement industry, which is responsible for 7% of total CO_2 delivered .

Ecological concrete can substitute up to 40% of common cement in the usual mixture used to prepare concrete

To further reduce the emission of greenhouse gases in the production of concrete, researchers successfully substituted 20% of ordinary cement with other substances such as sugar cane bagasse ashes, rice husks, or ceramic wastes and tile powder.

Measures shows it can reduce the lobal cement industry in up to 2.3 millio

Research and Development in

Alternative Energy Sources

Alternative Energy Sources

Hydrogen powered bus

In 2010 COPPE has launched a Hydrogen powered bus

Designed to have an autonomy o 300 km, using only the energy from:

- **a nationally manufactured hydrogen fuel cell ,**
- **electricity from kinetic energy regeneration in breaking and from the grid accumulated in batteries.**

The project stands out because of its innovative engineering and
low cost, nearly 50% less than the price of the European version.

Biodiesel Plant of IVIG/COPPE

Visit of the President

Garbage → Biodiesel

Electric Energy from Waste at Federal University of Rio de Janeiro

30 t/day

Wave Power Plant

COPPE has developed a Project for the implantation of the first ocean wave power plant in South America. A pilot plant, capable of generating 500 kW, being implanted in Ceará, in the Northeast Region of Brazil.

The pilot power plant design includes a hyperbaric chamber (an equipment developed in COPPE to simulate high pressure marine environments in offshore oil production) capable of producing water pressure equivalent to 500 meter high waterfall, like that of a hydroelectric power plant.

Initial studies show that the Brazilian coast has the potential for supplying 15% of the total of the electricity consumed in

With 8.5 thousand kilometers of co and about 70% of the population occupying coastal regions, Brazil offers very favorable conditions for obtaining significant advantage from this source of abundant, renewable and nonpolluting energy which avoids CO2 emissions.

Brazilian Forum on Climatic Change

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