FORESTRY BIOMASS AS A FEEDSTOCK FOR ENERGY PRODUCTION IN CHILE: CHALLENGES AND OPPORTUNITIES

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Bio refinerí Materiales y En

Contents

- Global outlook
  - Sustainability challenges
  - The energy issue
  - Biofuels
- Chile
  - Energy matrix and challenges
  - Lignocellulosic biomass as a source of energy
  - Social and environmental implications
- Conclusions

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PARKING
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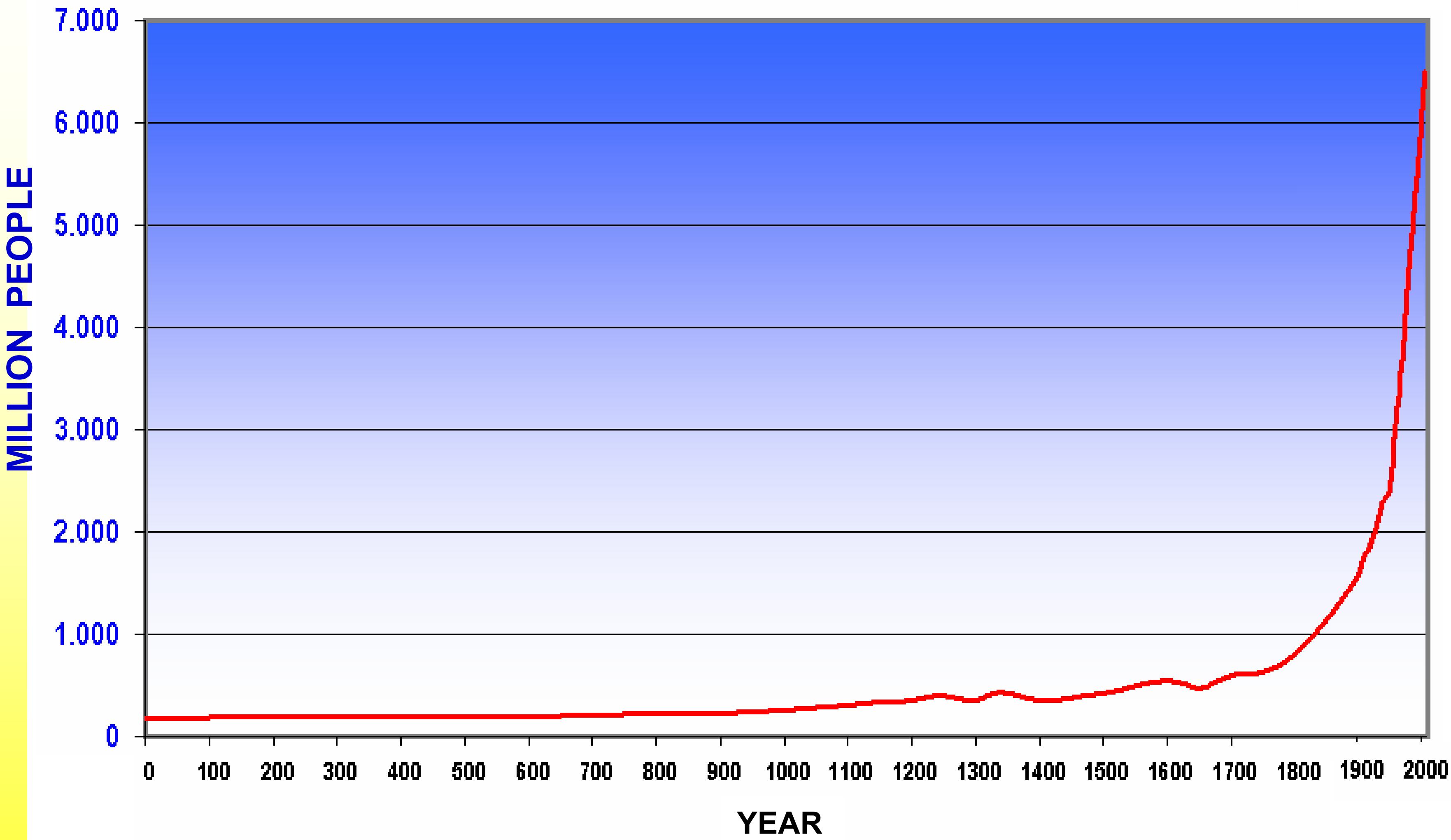
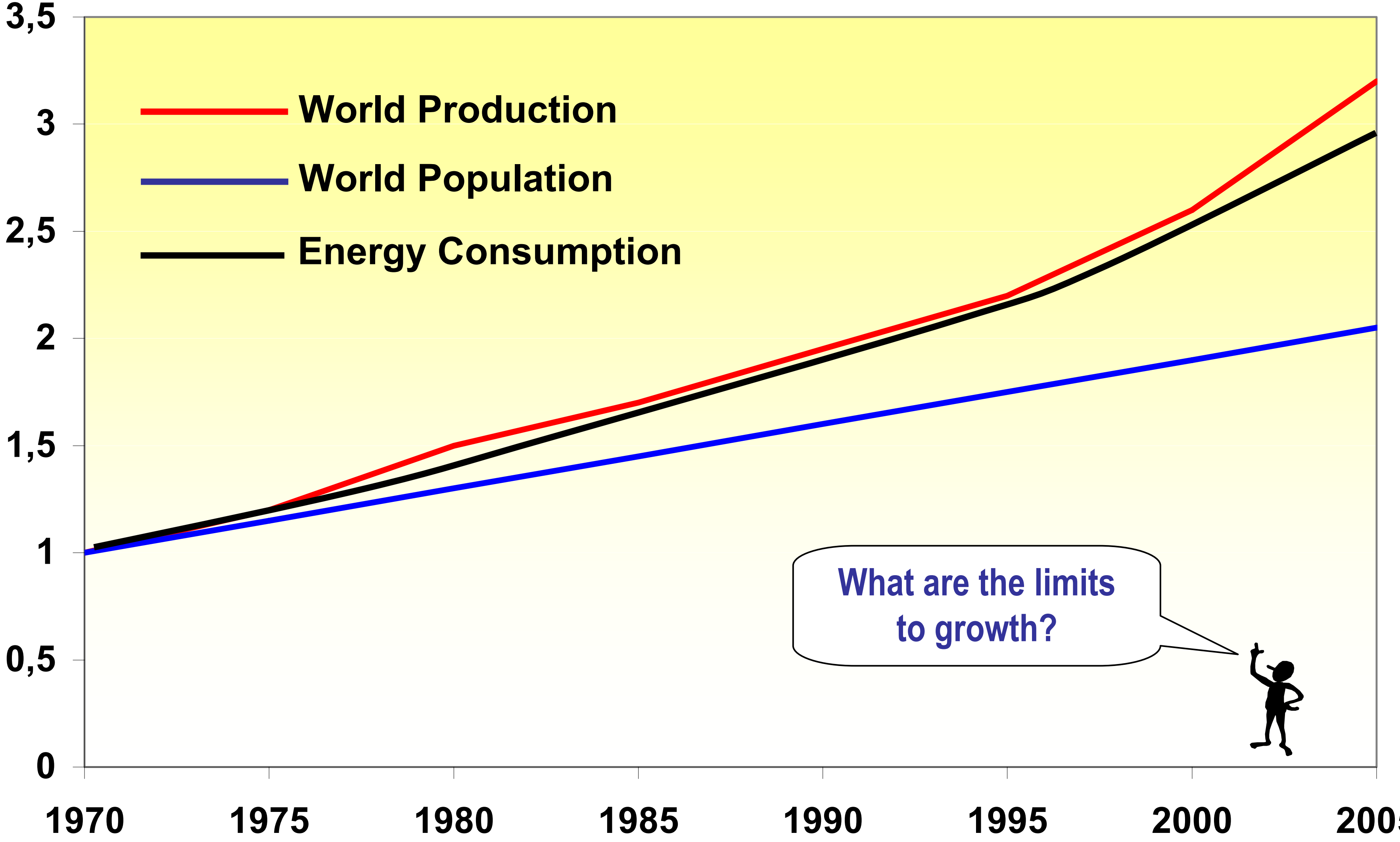
World Population



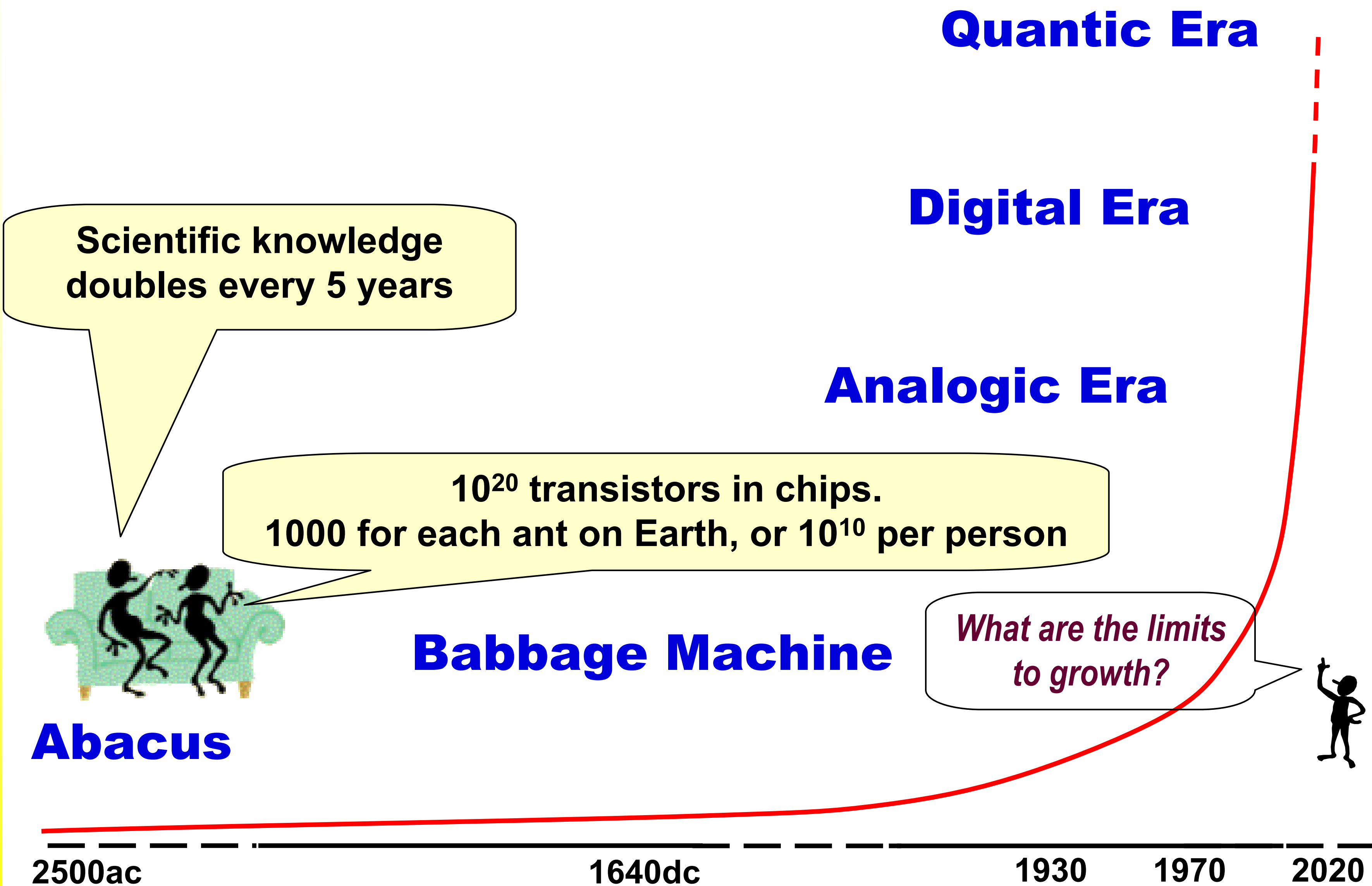
World Population : 6,777,513,139 ***Updated*: 4 May 2009; 02:52 GMT**

Source: U.S. Census Bureau, Population Division, International Programs Center.

World Growth 1970 - 2005



Exponential advances in Science and Technology



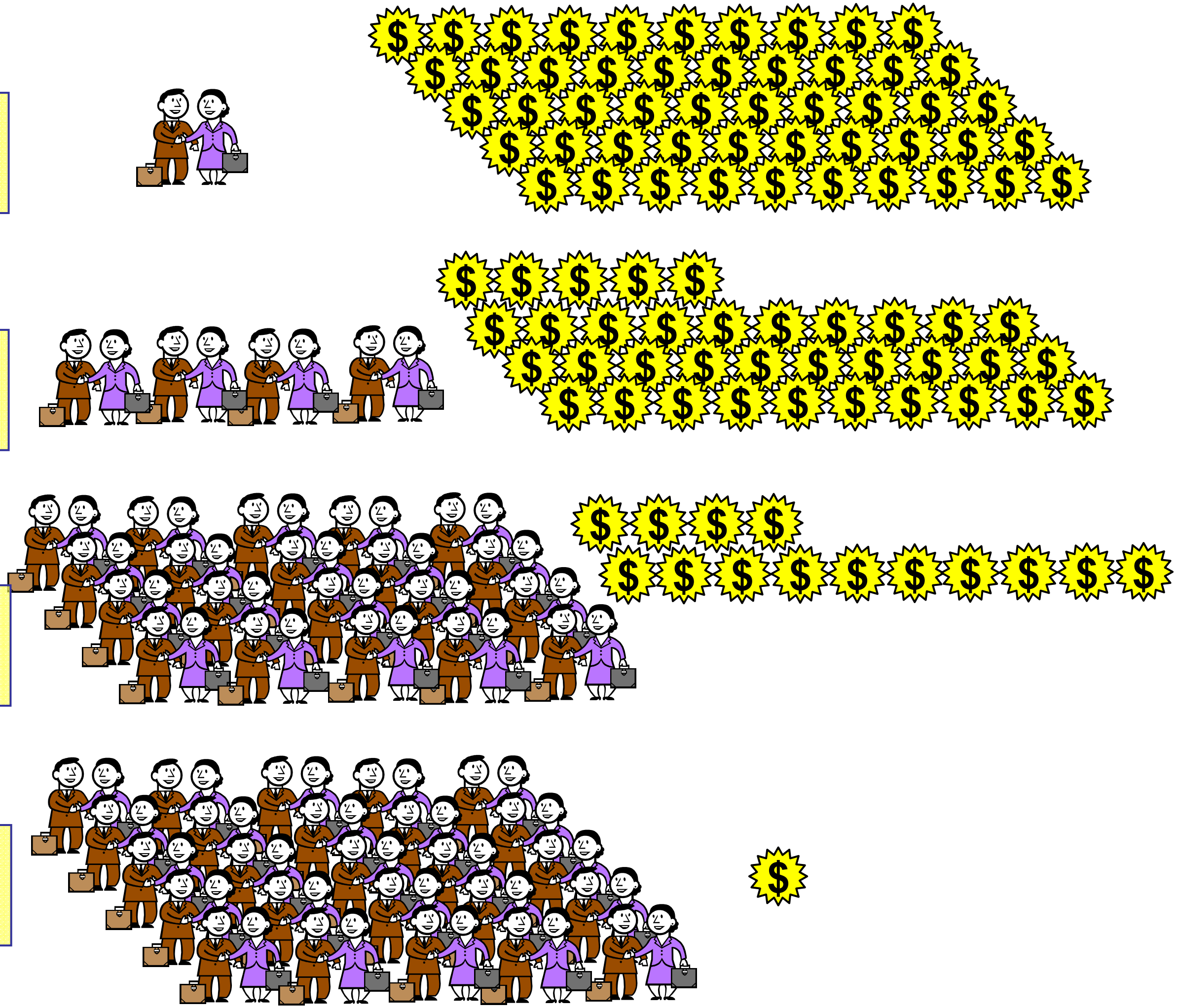
World Income Distribution

2% population earns 50% world wealth

8% population earns 35% world wealth

40% population earns 14% world wealth

50% population earns 1% world wealth



Source: World Bank (2007)

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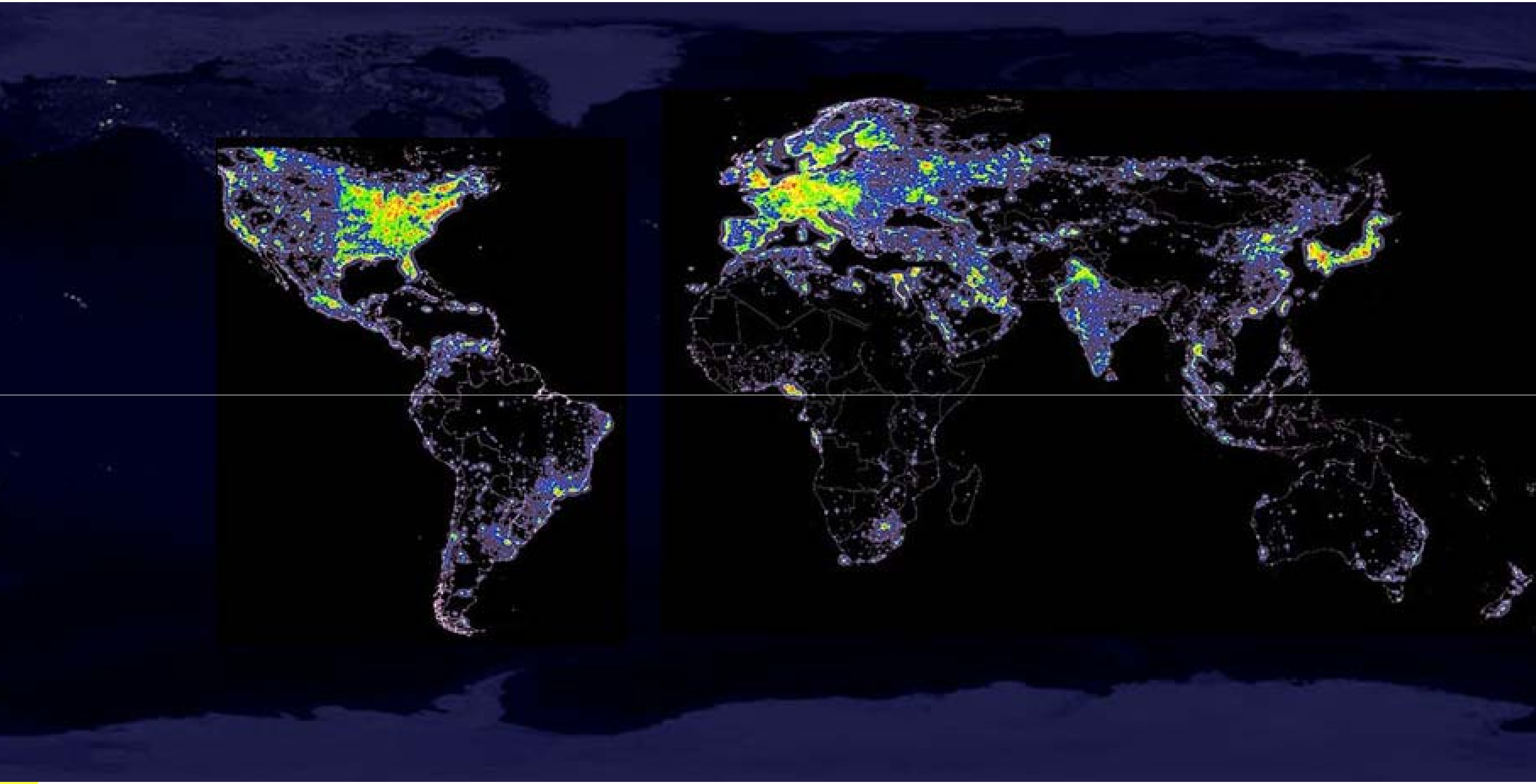
Energy consumption in the World

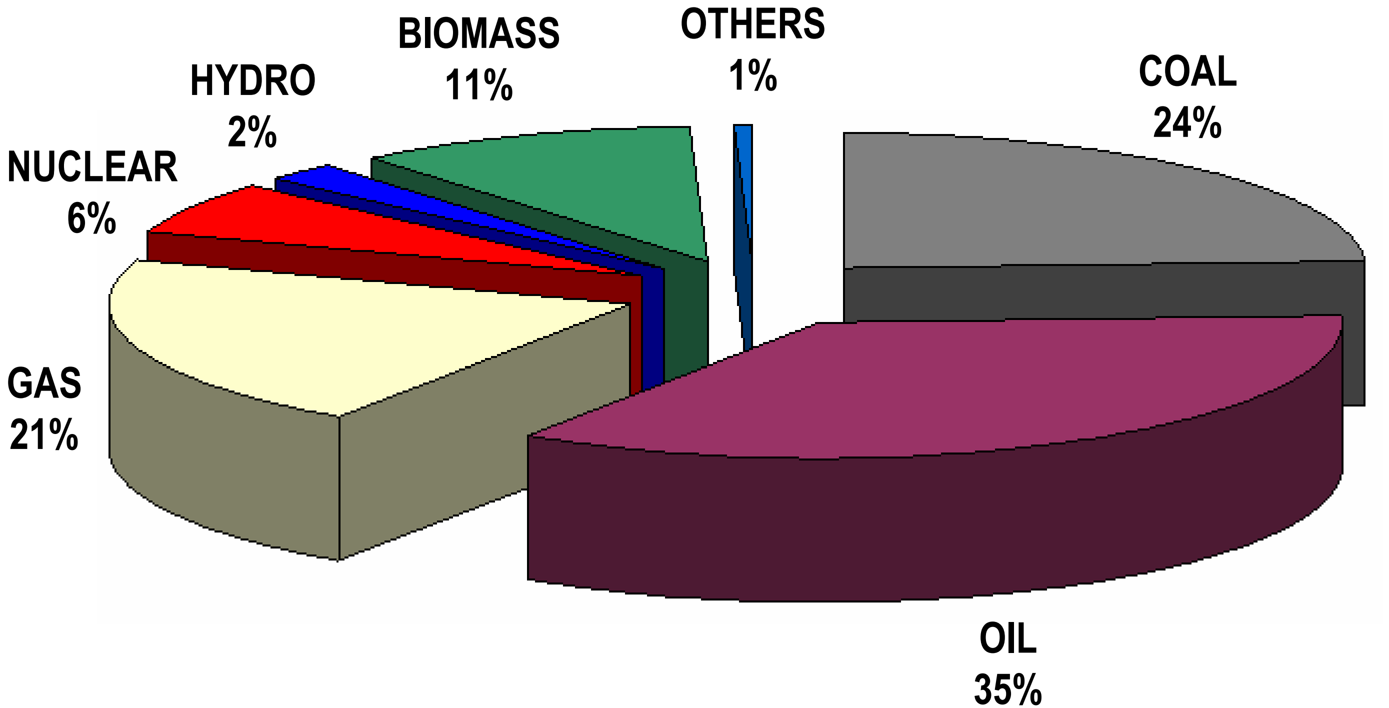
12.000 Millions toe / year



Over 90% world population in the Northern Hemisphere

World Primary Energy Sources

12.000 Millions toe / year



90% from combustion processes !

8 Gton C / year = Impacts on global T and climate

OIL: Basis of Modern Industrial Society

Global Oil Reserves:

144,000 million ton oil (140-180,000 million)

Current Consumption:

4,000 million tons /year

$$\frac{144.000.000.000}{4.000.000.000} = \text{36 years !!!!}$$

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Oil Market Structure

Bio refinerí Materiales y En

OIL PRODUCERS	Mton	
Saudi Arabia	519	14%
Rusia	470	12%
USA	307	8%
Iran	205	5%
Mexico	188	5%
Rest of World	2.234	

OIL EXPORTERS	Mton	
Saudi Arabia	346	16%
Rusia	258	12%
Norway	132	6%
Iran	122	6%
Nigeria	122	6%
Rest of World	1.173	

OIL IMPORTERS	Mton	
USA	577	26%
Japan	206	9%
China	123	6%
Corea	114	6%
Germany	110	6%
Rest of World	1.105	

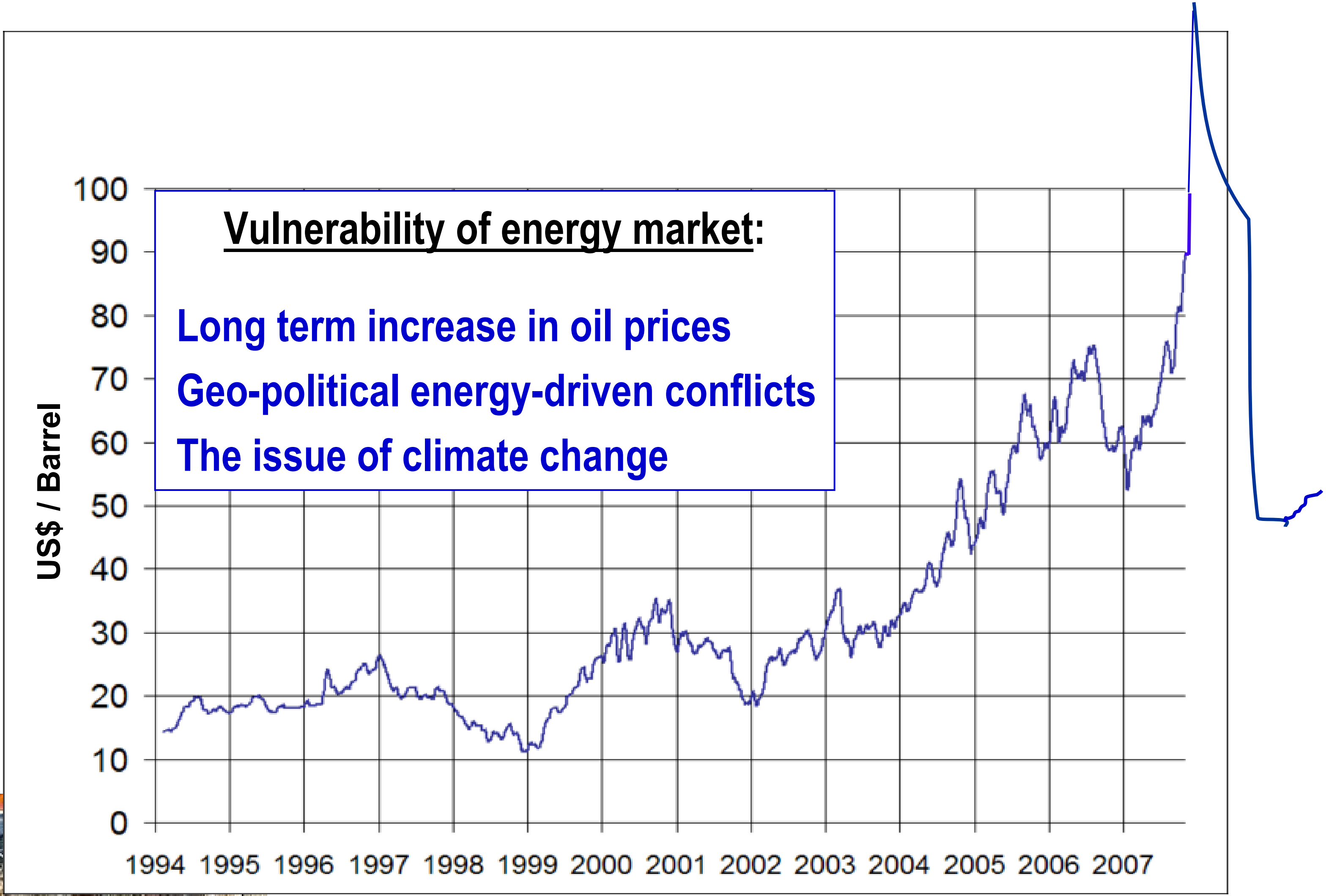
Oil Prices 1994 – 2007

Vulnerability of energy market:

Long term increase in oil prices

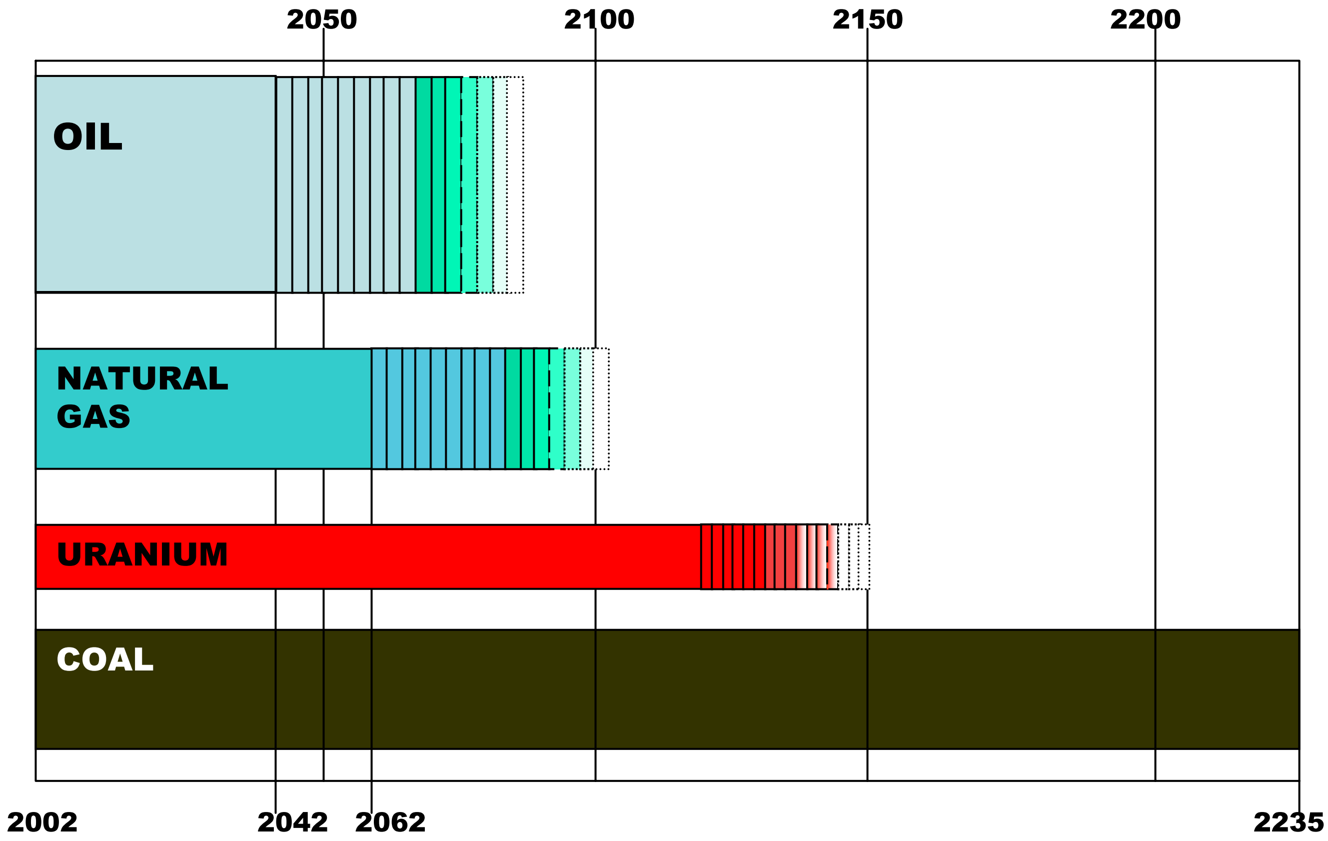
Geo-political energy-driven conflicts

The issue of climate change



Limited Amount of Fossil Fuels

Reserves According to Current Consumptions



Source: British Petroleum, 2005

Declared reserves should grow as energy prices go up!

Renewable Fuels

Biofuels:

Fuelwood
Charcoal
Fat & oils
Biological Residues
BioEthanol
Biodiesel
Biogases (CH_4, CO, H_2)

HEAT
TRANSPORT FUELS
ELECTRICITY

BIOFUELS

Sources:

Wood
Oily Plants
Animal Fats
Fermentable Crops
Microorganisms
Algae

Direct Combustion

(eg. fuelwood, charcoal, sludge, vegetable residues)

Fuel Extraction

(eg. vegetable and animal oils/fats, biodiesel)

Thermochemical Transformations

(eg. solid, liquid ans as fuels, from biomass pyrolysis or gasification)

Biological Transformation

(eg. Anaerobic digestion (biogas), alcoholic fermentación (bioetanol), enzymatic processes)

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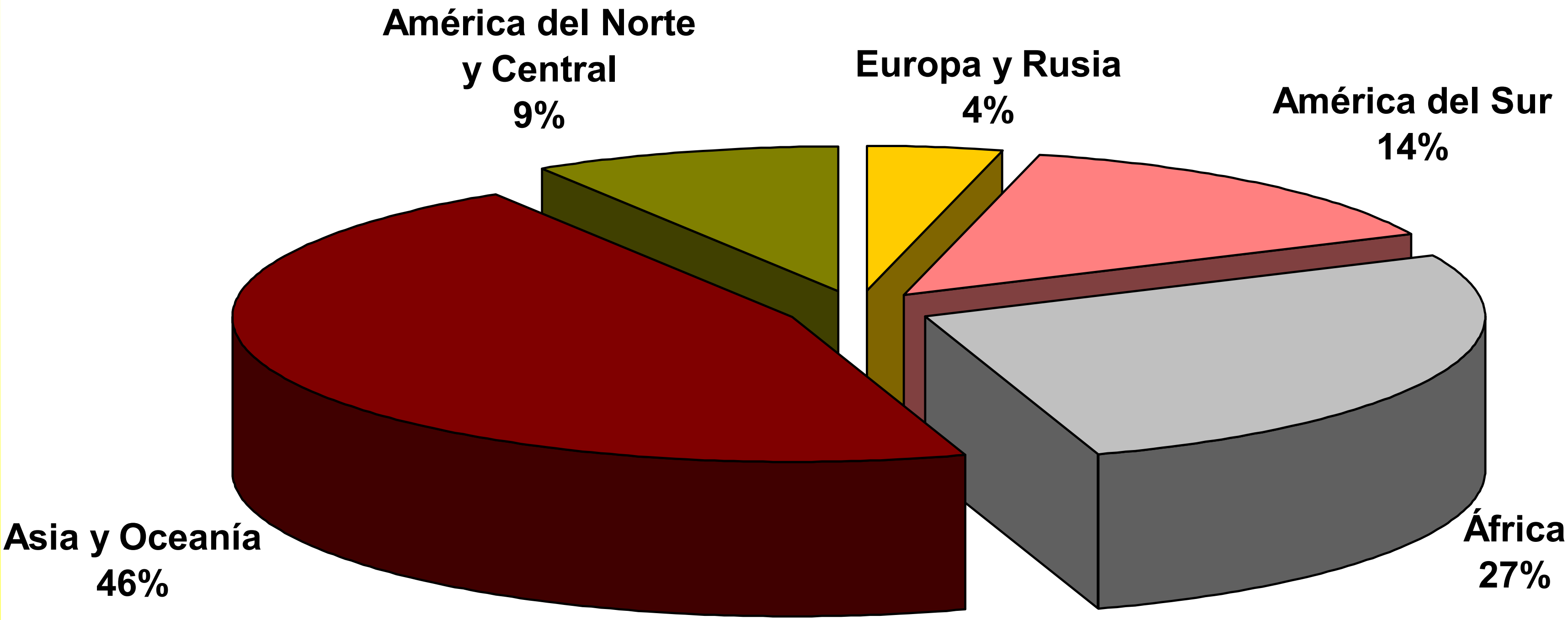
World Fuelwood Consumption

4,000 million ton / year



800-1.500 million ha / year

Industrialized countries account for less than 10% of world fuelwood consumption

BioDiesel

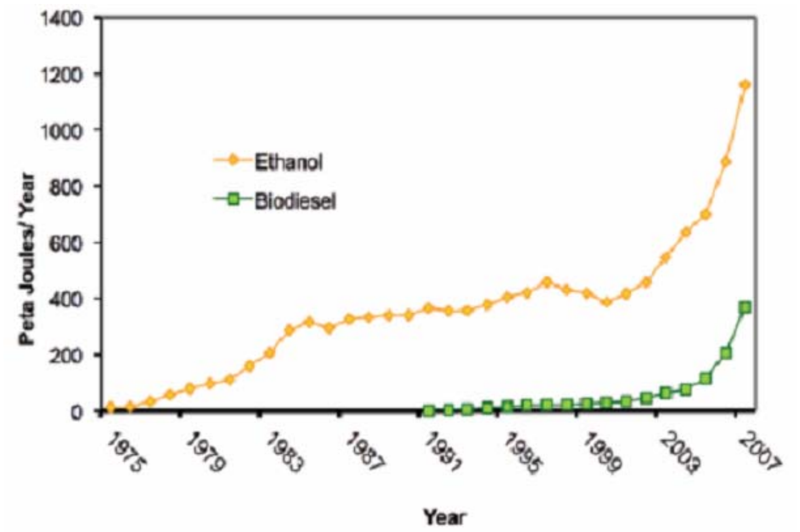
Germany	63%
France	17%
USA	10%
Italy	7%
Austria	3%

9 million ton/year (from raps, canola, soy and used oils)

BioEthanol

USA	36%
Brasil	33%
China	8%
India	4%
France	2%

40 million ton/year (from maize, sugar cane, beet, etc)



World Oil Consumption: 4,000 million ton / year

Land Use for Fuel Crops

- 2007: 27 million ha. for biofuels
- 2008: 36 million ha (2% global cropland)
- Expansion mainly in high yield tropical countries

<u>BRASIL</u>

Sugarcane 9 mill ha (2008)

Potential for Soybean: 100 million ha

Grassland and tropical forests replaced by energy crops

<u>INDONESIA</u>

Most Oil Palm plantations on forest land

Expected expansion from 6 to 25 million ha

Tropical forests replaced by energy plantations

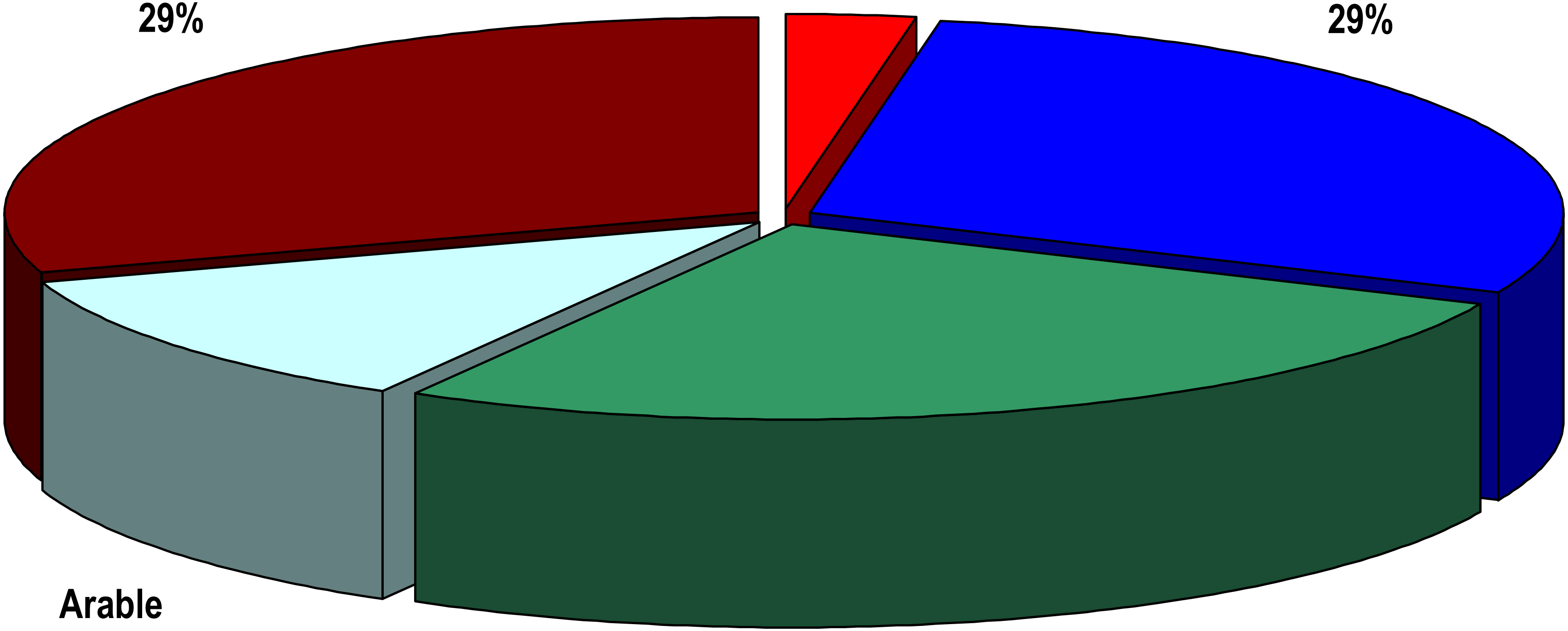
Estimates of global biofuels and cropland requirement for transport uses

Energy Contribution	Land Requirement	Yield	Source
92 Mtoe	35 Mha	2.6 toe/ha	IEA (2006)
147 Mtoe	53 Mha	2.8 toe/ha	IEA (2006)
294 Mtoe	59 Mha	5.0 toe/ha	IEA (2006)
339 Mtoe	118 Mha	2.9 toe/ha	Ravindranath *et al* (2009)
611 Mtoe	160 Mha	3.8 toe/ha	IEA (2008)

4-8 m^3 ethanol /ha /year
1-6 m^3 diesel /ha/year

World Oil Consumption:
4,000 million ton / year

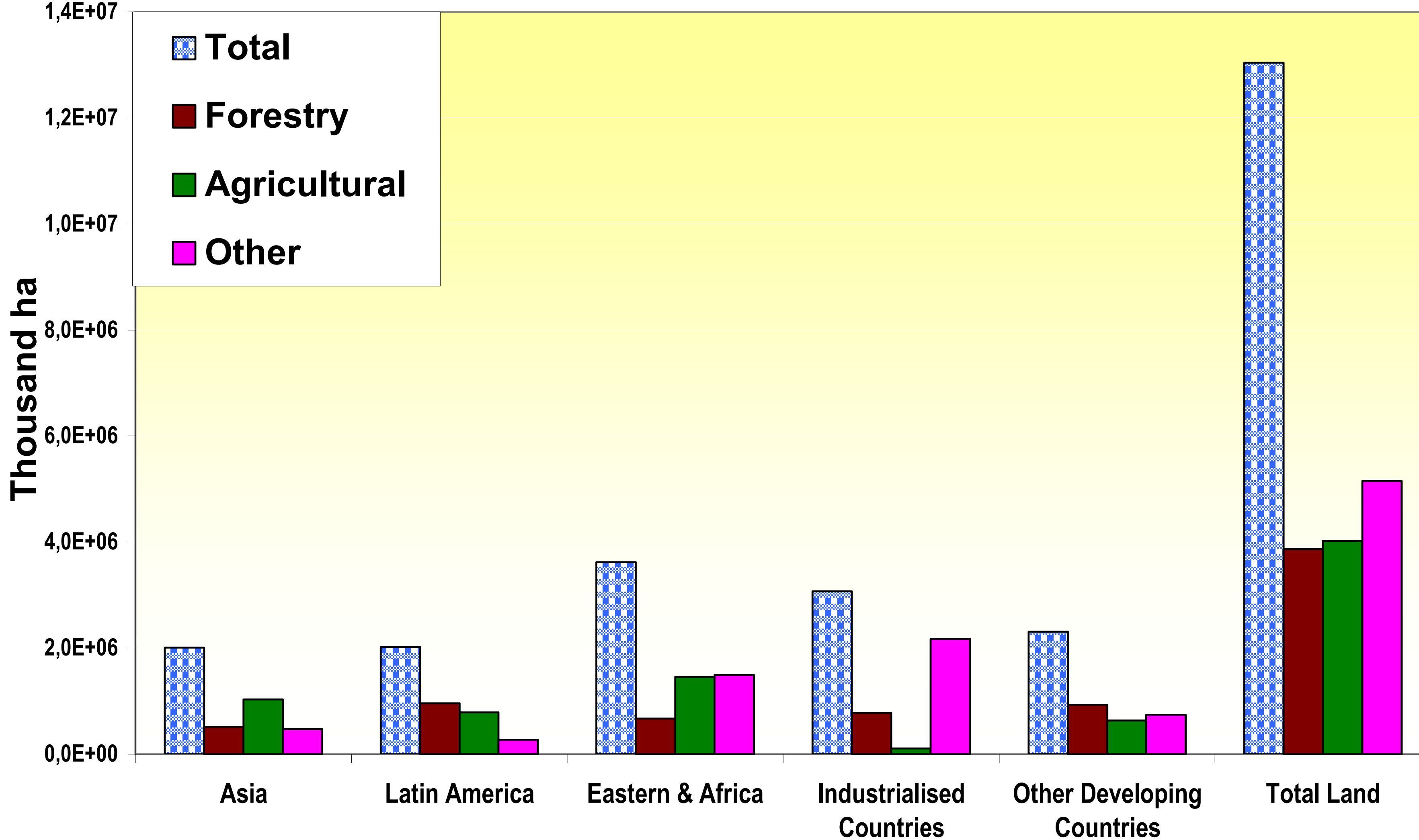
Global Land Uses



Total Land	*13,000 million ha*
Forestry	*3,900 million ha*
Agricultural	*5,000 million ha*

1 km^2 = 100 ha

Global Land Uses



1 km^2 = 100 ha

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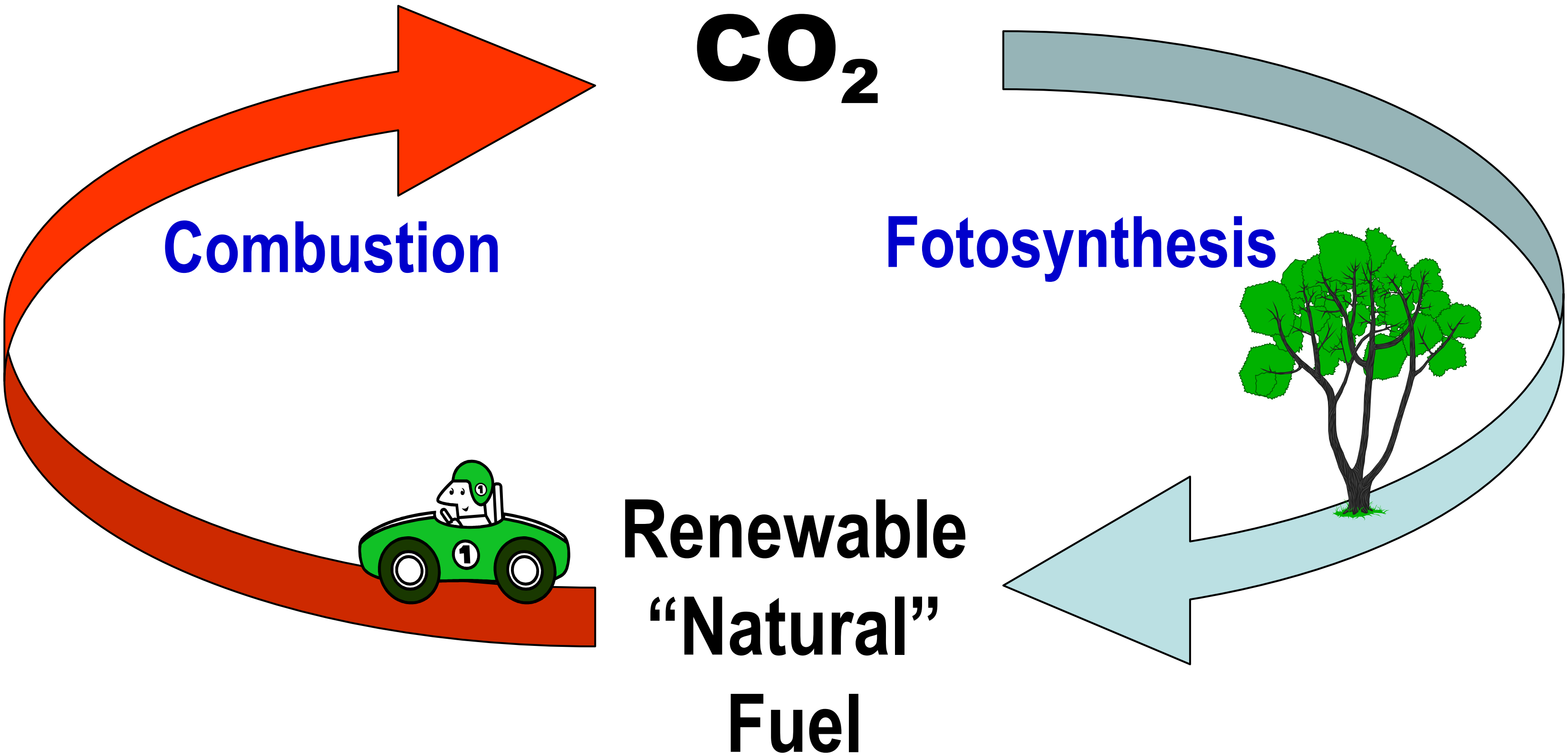
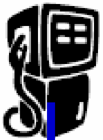
The Carbon Balance



Biofuels Life Cycle

Resources	Processing	Transport	Use
Agricultural Products	Pre-harvesting	Biogas	
Forestry Products	Harvesting	Biodiesel	
Vegetable, forestry, animal wastes	Grinding	Bioethanol	
	Extraction	BTL	
	Hidrolysis	Charcoal	
	Fermentation		
	Gasification		
	Pirolysis		
	Purification		

Biofuels Life Cycle

Land use for biomass growth

Industrial and transport infrastructure

Electricity and fuels for transport and industrial processing

Organic solvents and chemicals

Water, etc

Key environmental issues

- Carbon Balance: Fossil C vs Renewable C along the life cycle
- Negative effects on food markets, due to pressure on energy crops
- Reduction of pasture / forestry land due to expansion of fuel crops. Loss of biodiversity
- N_2O emissions from energy-crop production (1-10% N is emitted)

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CHILE

Continental Surface 756,250 km^2

Population: 16 10^6. 80% Urban

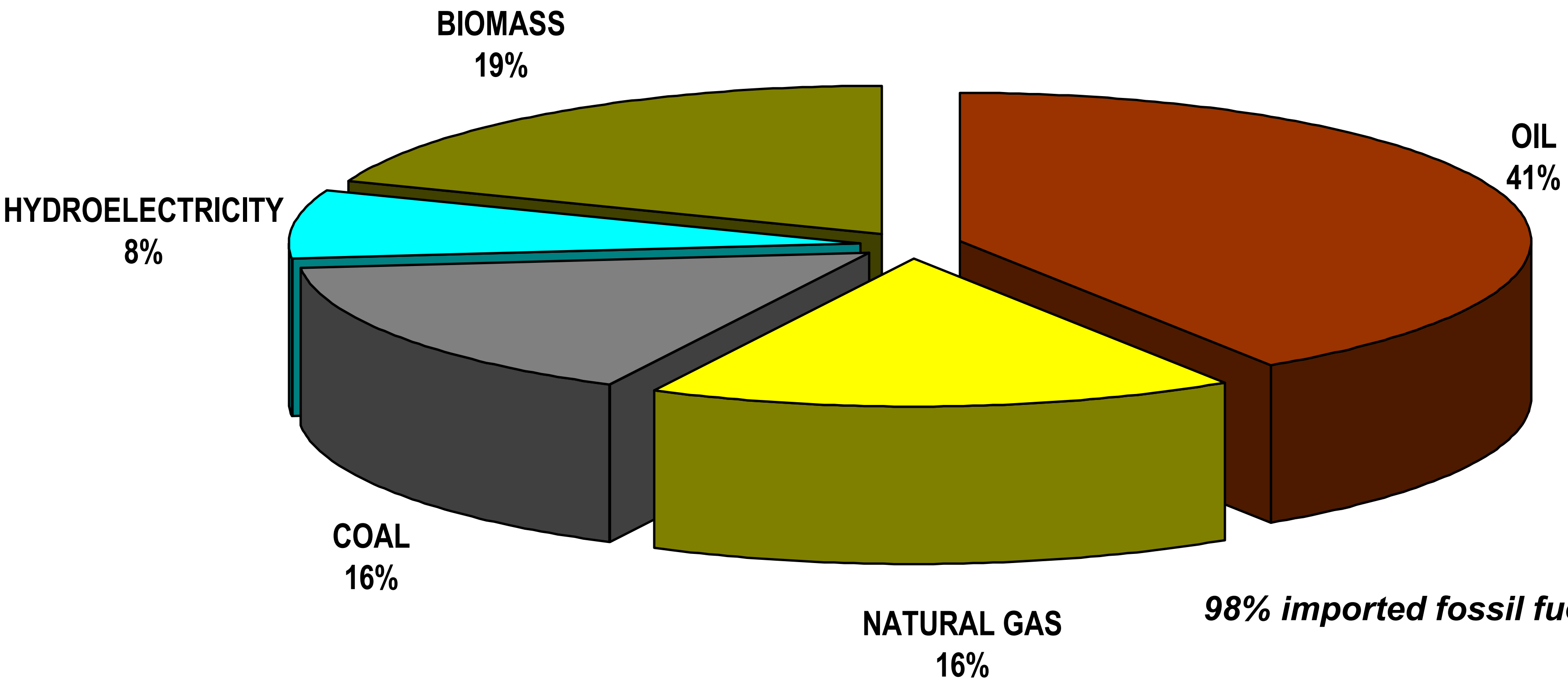
GNP: US$ 160,000,000,000 (2008)

3 MWh EE per capita /year

14 GW (38% hydro and 61% thermo)
(expected to double by 2024)

New thermoelectric plants, based mainly on coal.

PRIMARY ENERGY CONSUMPTION IN CHILE



98% imported fossil fuels

Total : 26,000,000 toe /year (2007)

1.6 toe per capita /year

$80 \cdot 10^6$ ton CO_2 emissions / year ***5 ton CO_2 per capita /year***

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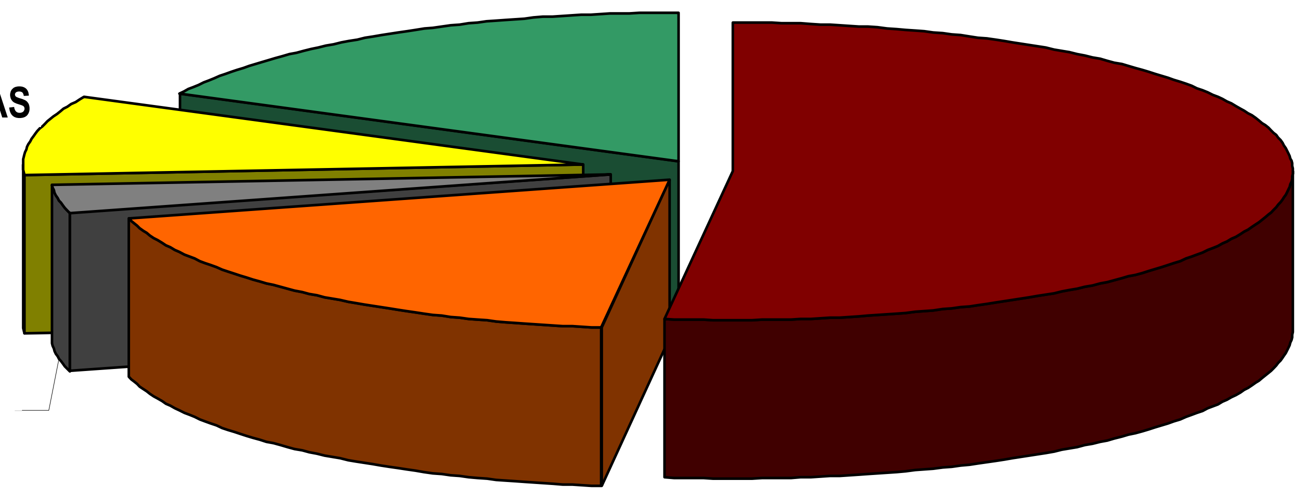
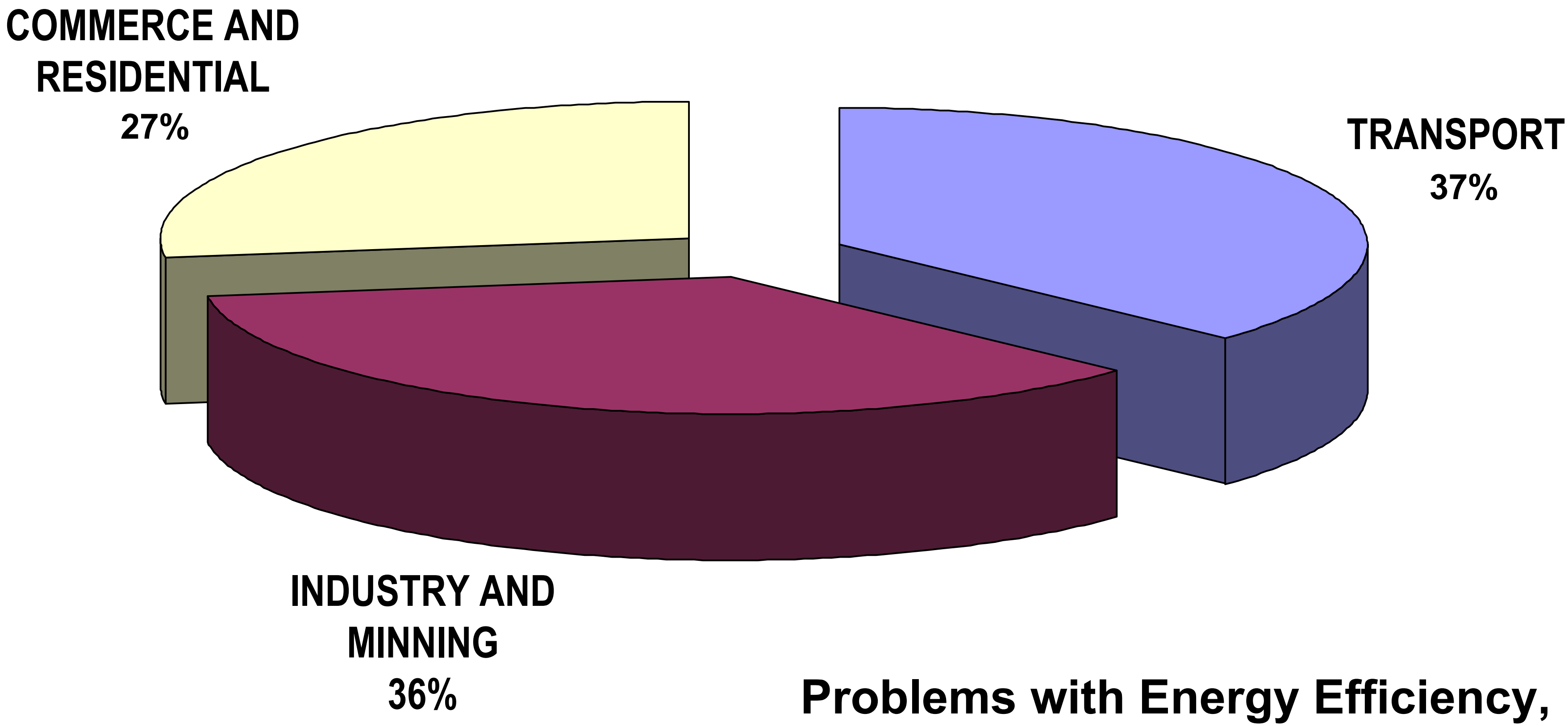
SECONDARY ENERGY CONSUMPTION IN CHILE



Total: 25,000,000 toe / year

Source: Comisión Nacional de Energía, Chile (2006)

FUEL AND ELECTRICITY CONSUMPTION IN CHILE



Problems with Energy Efficiency, in heating and power

Source: Comisión Nacional de Energía (2007)

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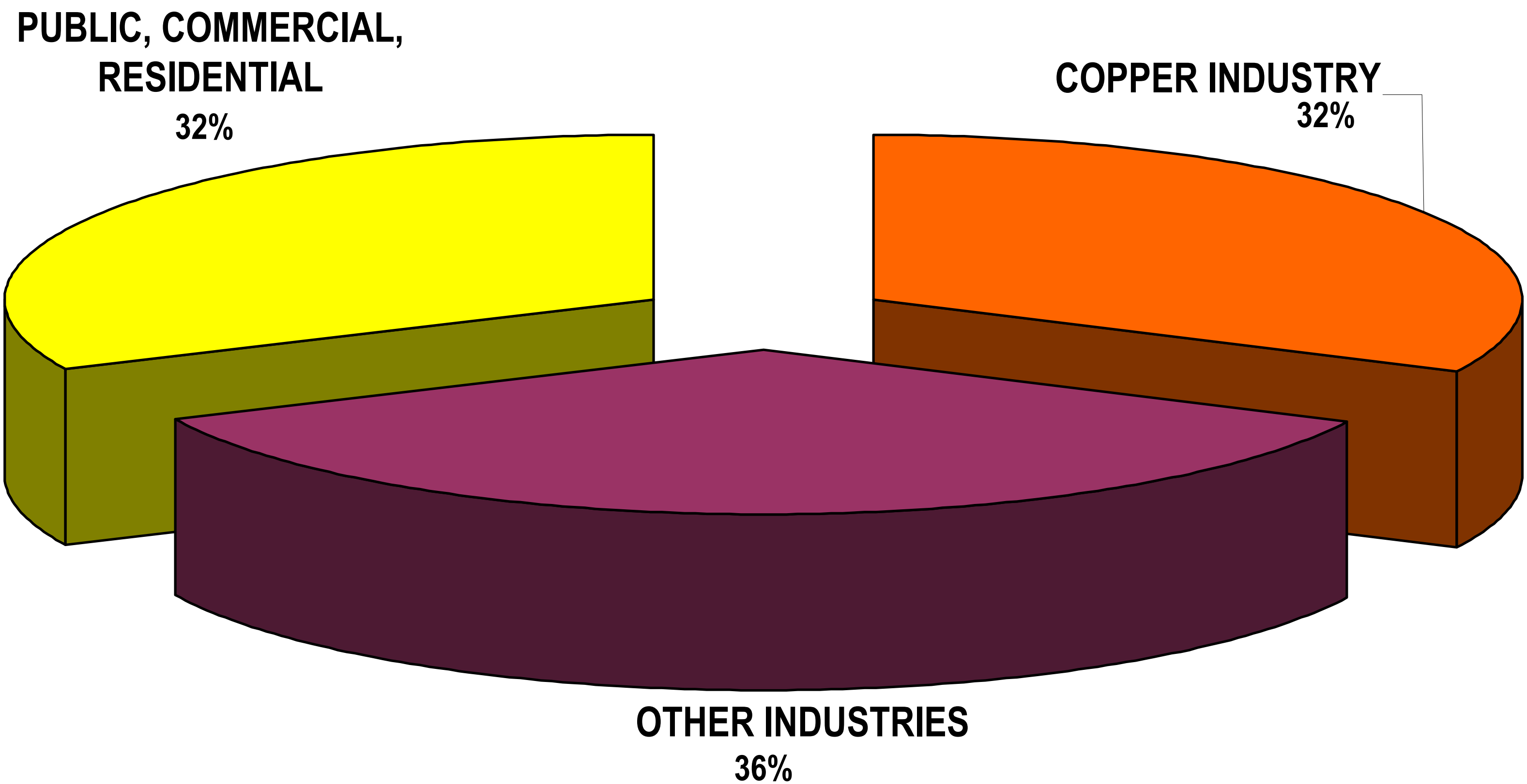
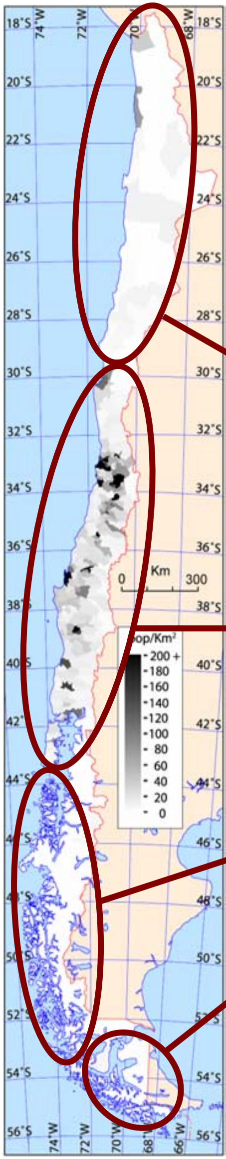
ELECTRICITY CONSUMPTION IN CHILE



TOTAL: 50.300 GWh /year

(2007)

Electricity Generation Systems in Chile



Pop. 1×10^6

Pop. 14 ×10^6

Pop. 0.3×10^6

Independent Grids	Installed Power Capacity	Primary Energy Source
Northern SING	3.6 GW	99% thermo
Central SIC	10.0 GW	40% thermo 60% hydro
Others	0.1 GW	88% thermo 9% hydro
Total	13.7 GW	

Hydroelectricity : 44% of total Electricity Generation Capacity

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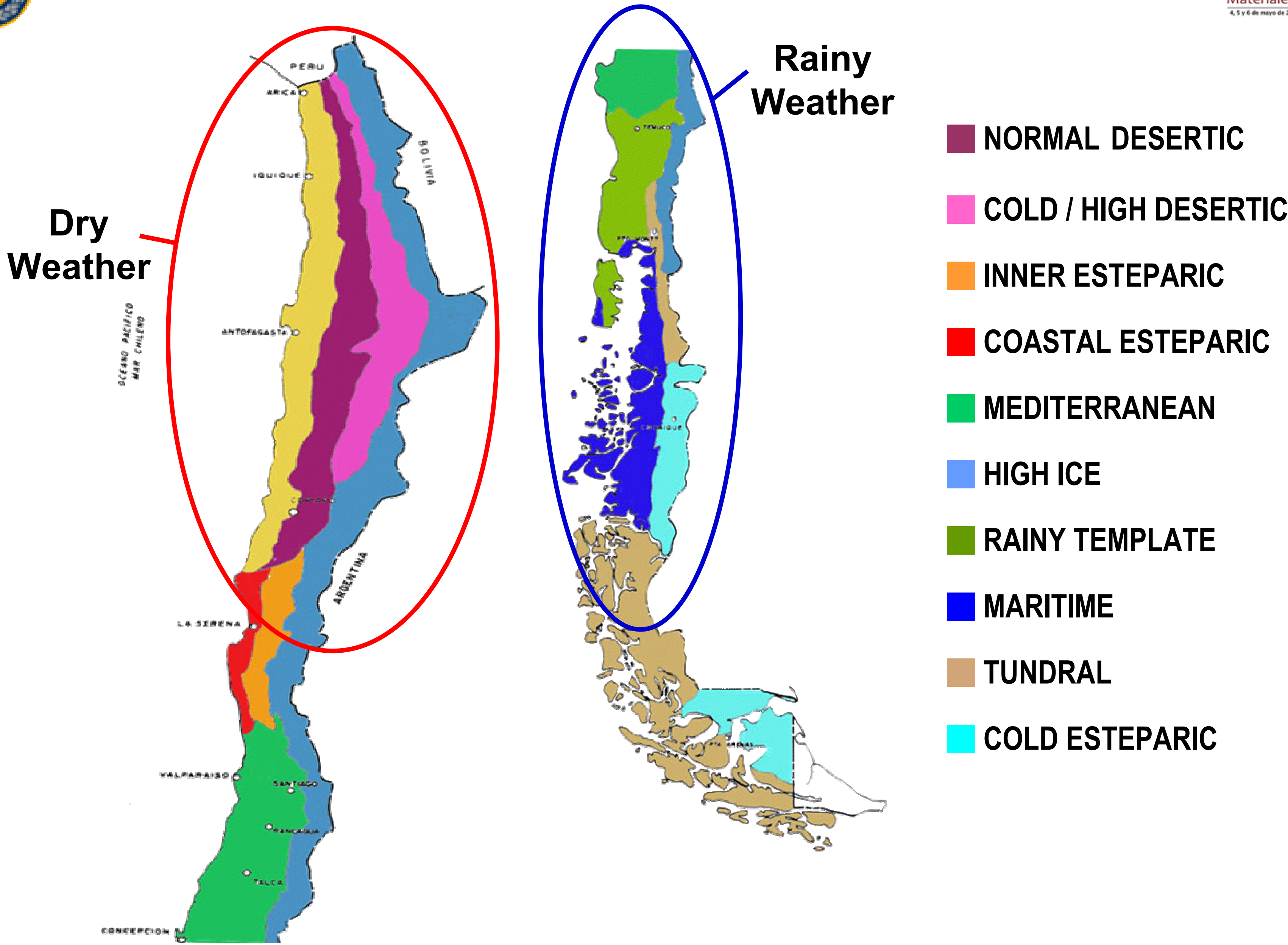
Chilean Climate: from desertic to antartic



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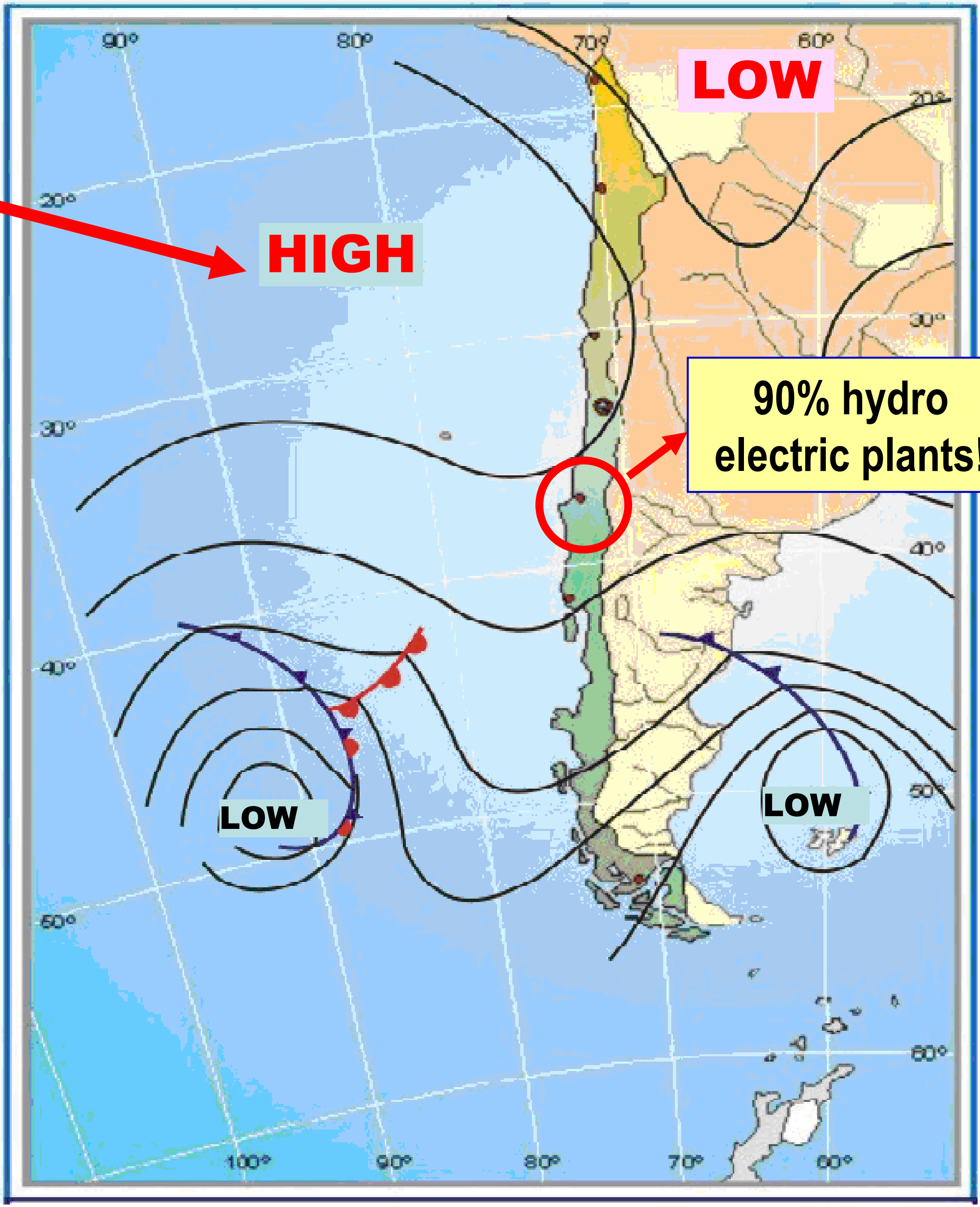
CHILEAN CLIMATE

South Pacific Anticyclon:

Key climatic determinant



<u>Climatic Determinants</u>:

✓ <u>South Pacific Subtropical Anticiclon</u>

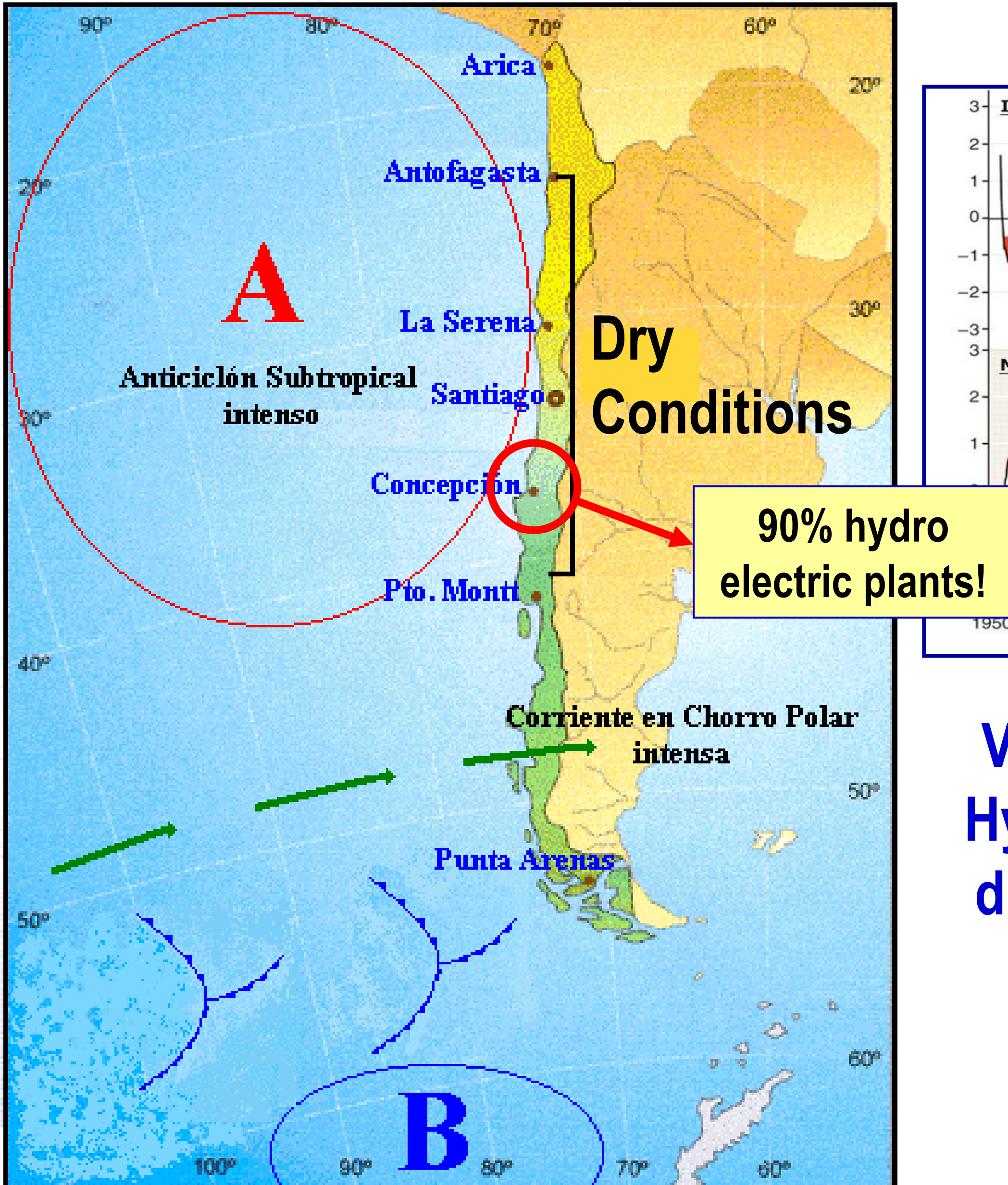
✓ <u>Low Pressure Systems</u>, associated to frontal systems.

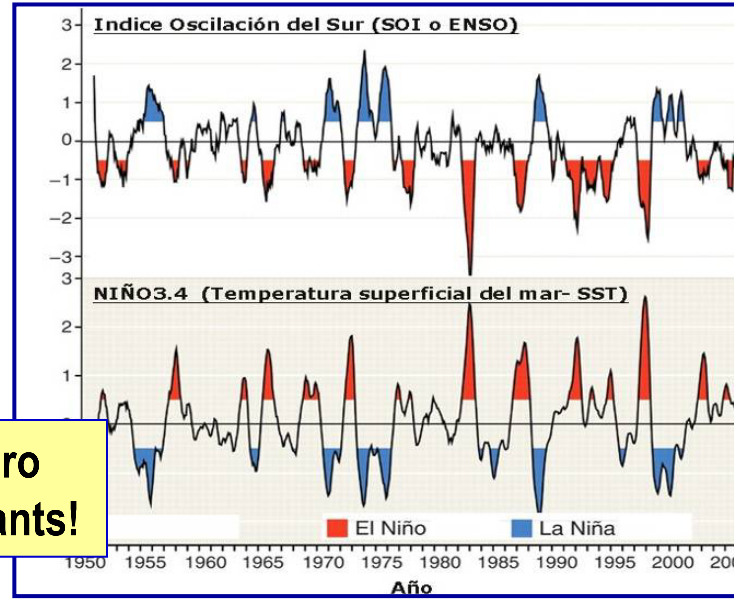
✓ <u>Cordillera de Los Andes</u>, isolate Chile from continental air masses

✓ <u>Humboldt Cold Current</u>, tends to homogenise temperature along Chilean coasts.

✓ <u>El Niño (wet) and La Niña (dry) conditions</u>

LA NIÑA 1998





Vulnerability of Chilean Hydroelectric Resources due to El Niño Southern Oscillation (ENSO)

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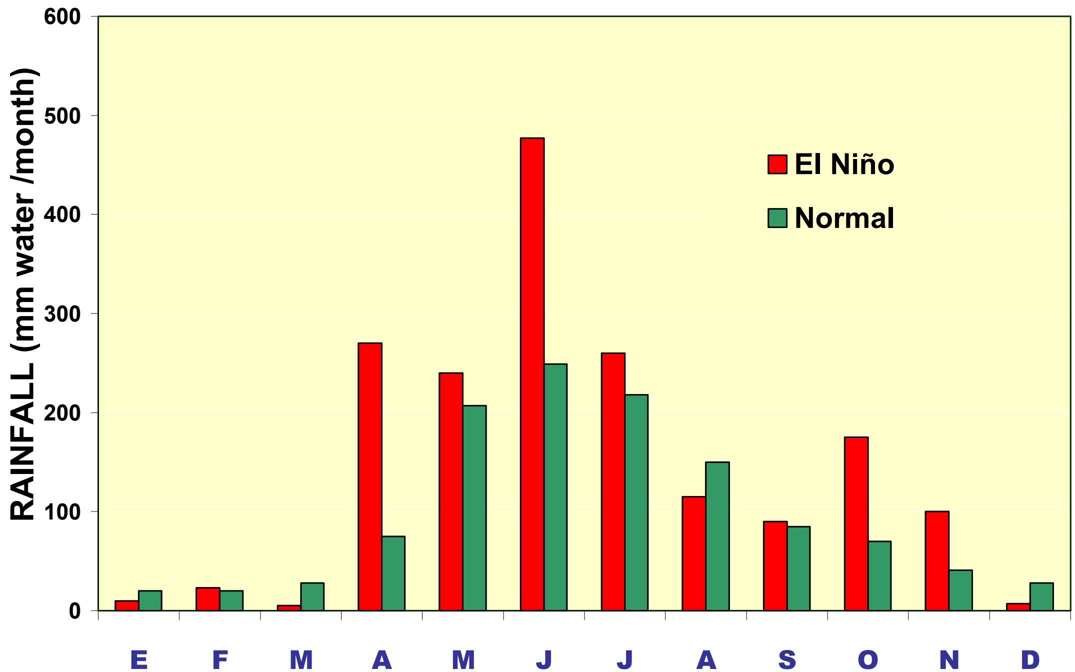
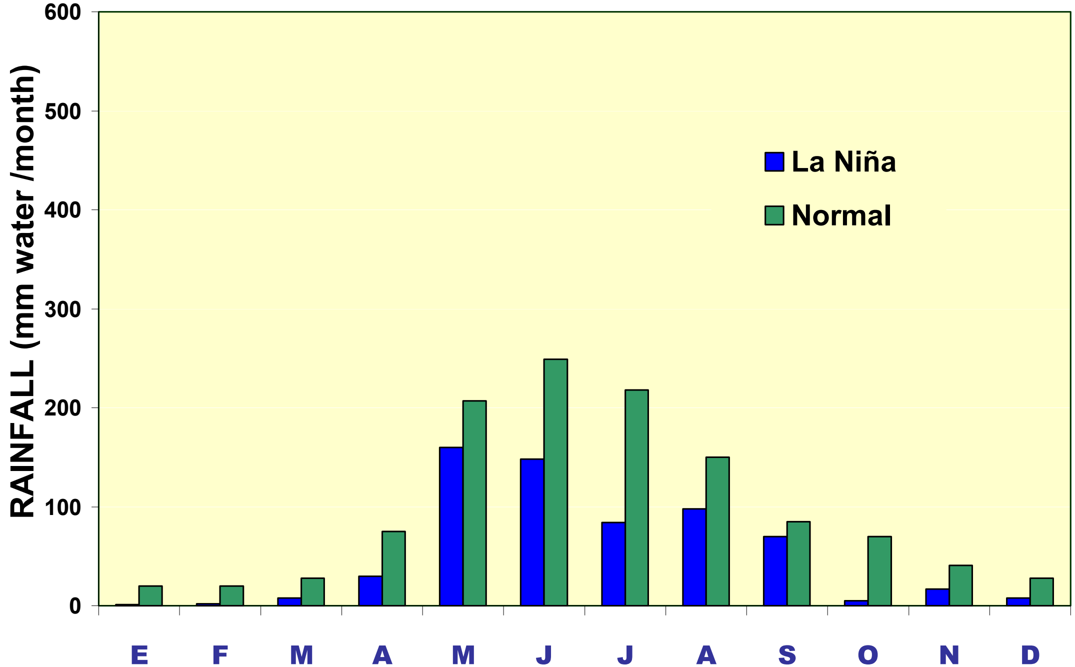
RAINFALL IN CONCEPCION (Bio Bio Region)



El Niño condition



La Niña condition

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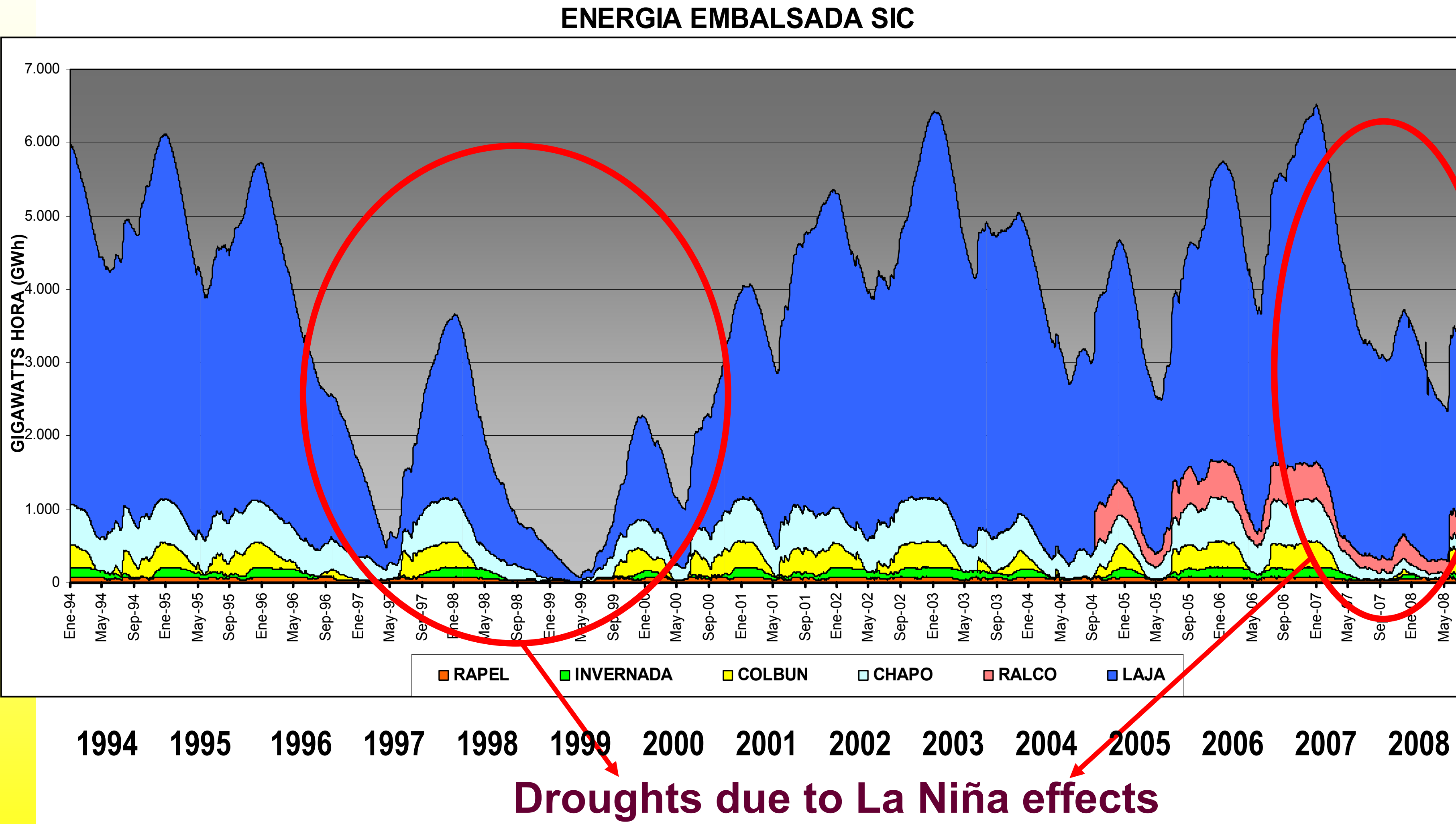
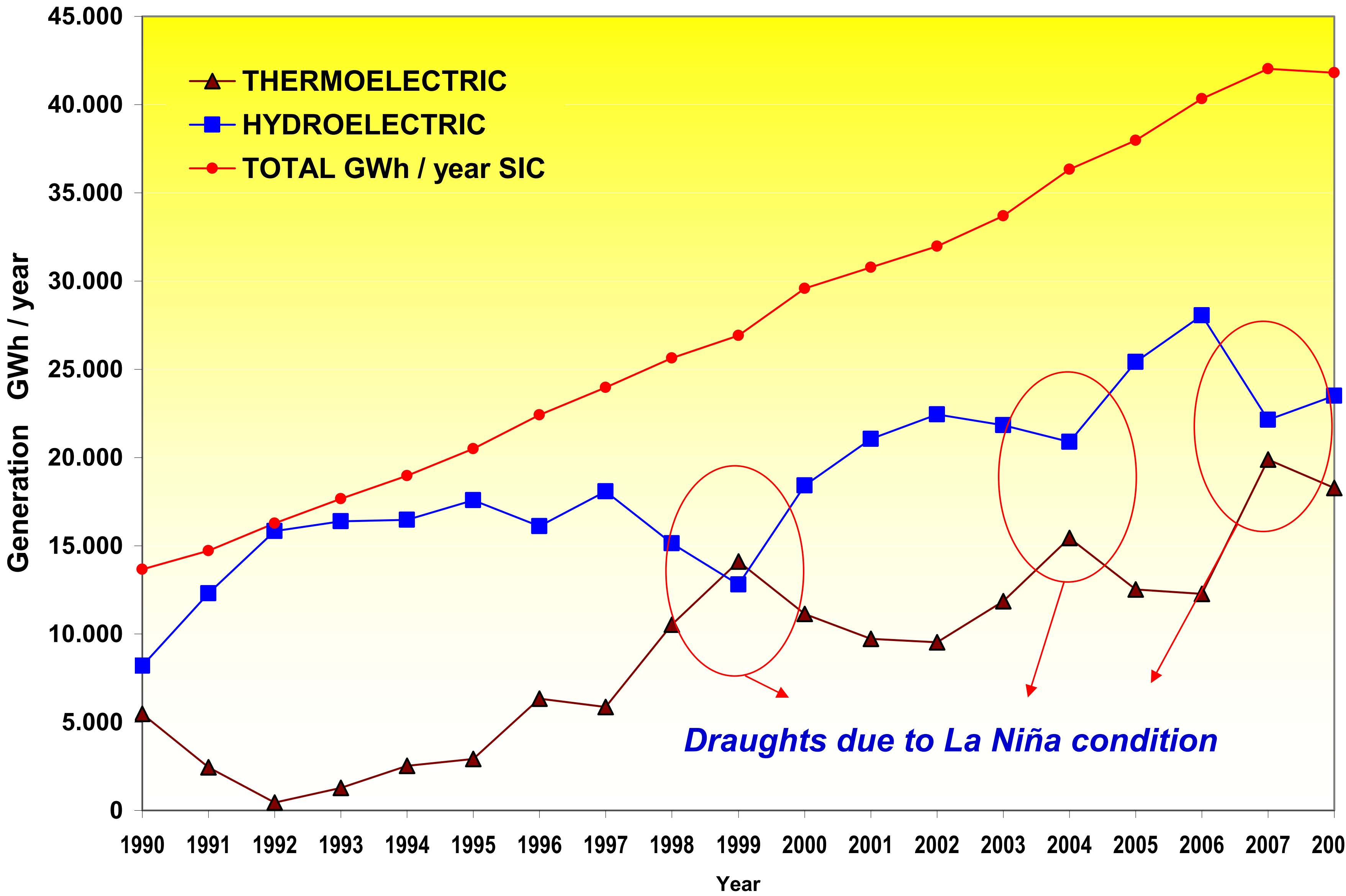
ENSO Efects on Hydro Electric System in Central Chile



Effect of La Niña Condition on SIC Electricity Generation



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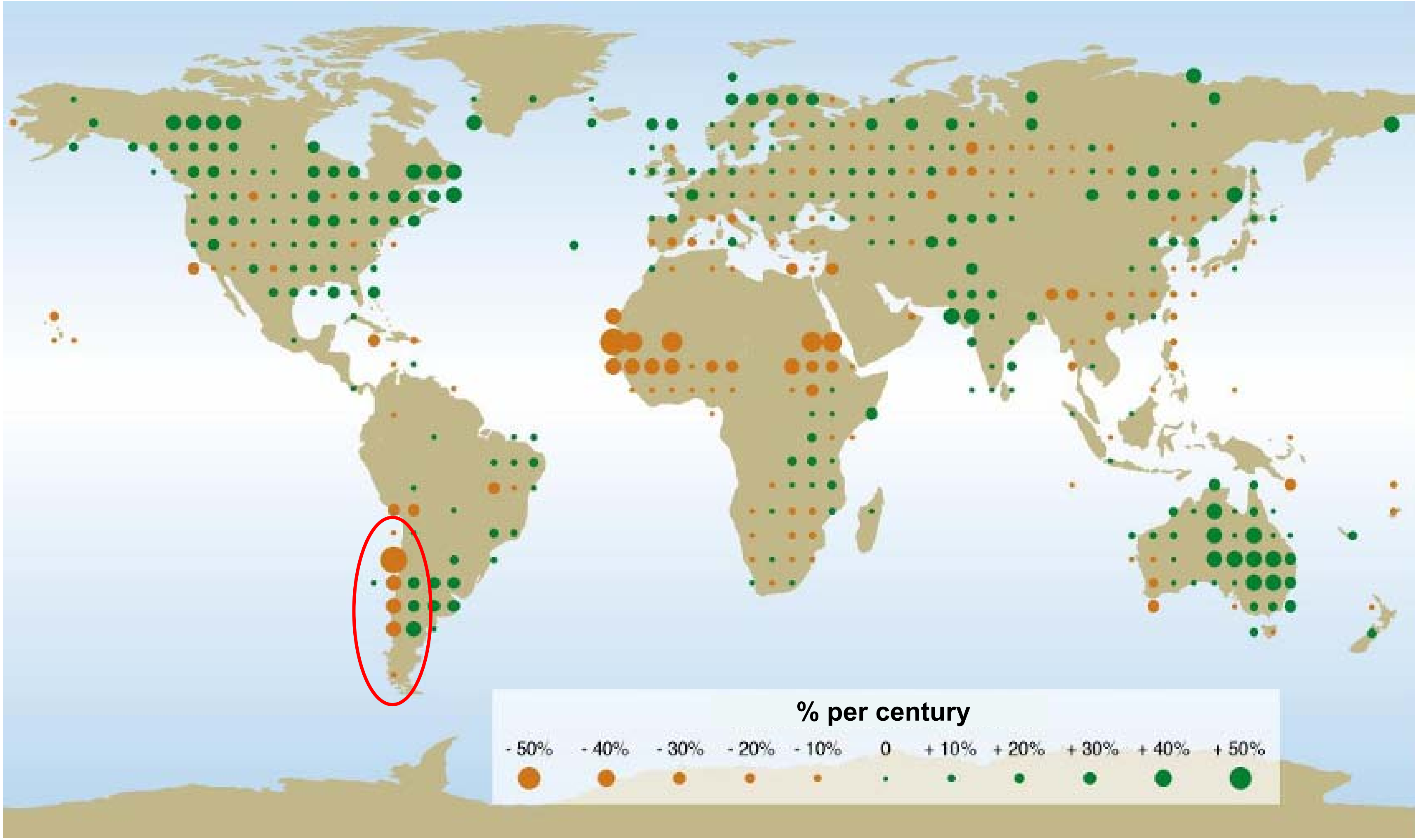
Rainfall Trends 1900 - 2000



Impact of climate change on global and local water cycle

Over 50% loss of Chilean water resources in the last 100 years!

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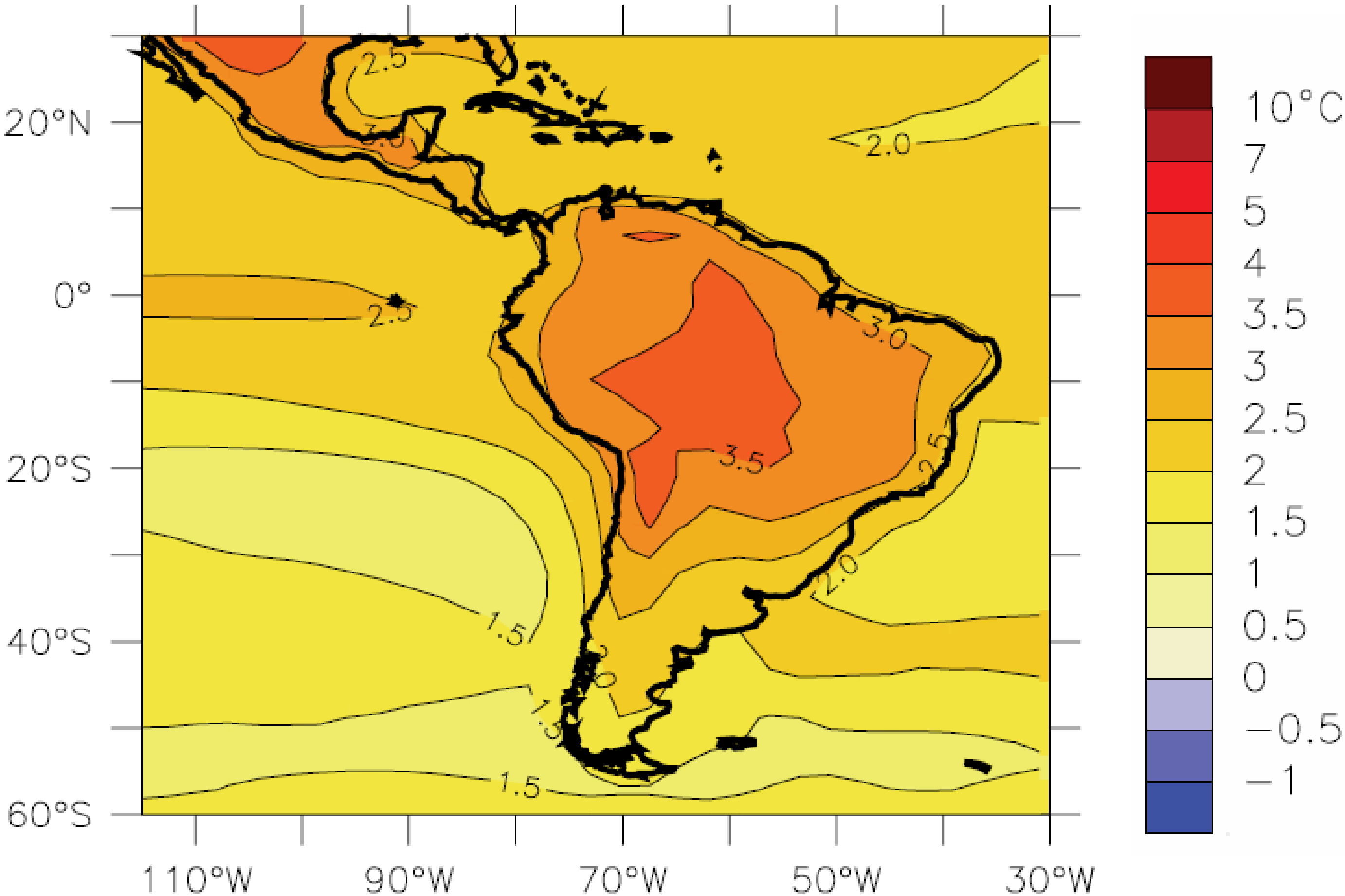
Mean Annual Temperature Changes

1980/90 - 2080/99



Expected Impact of climate change on South America

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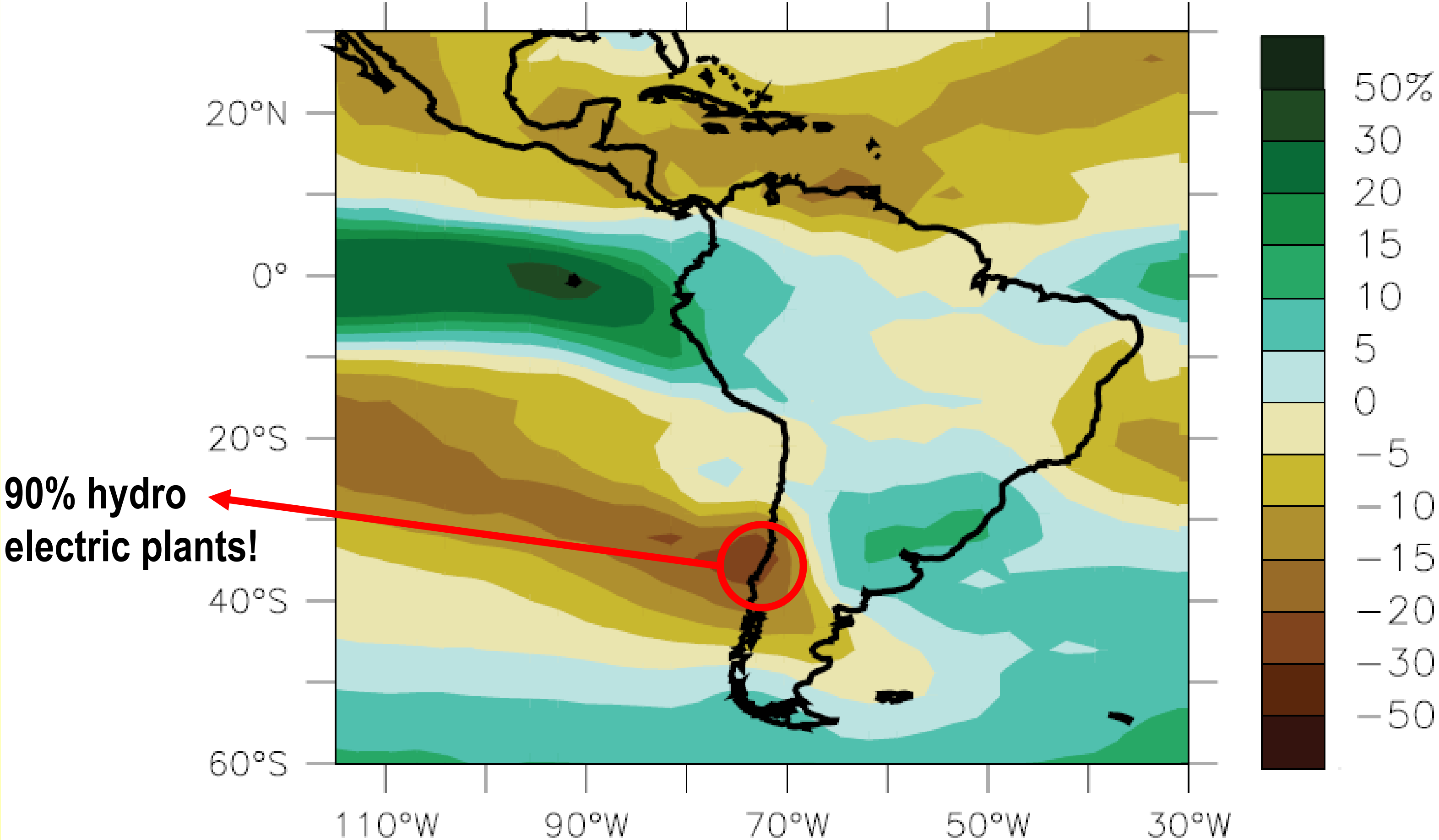
Mean Annual Rainfall Changes

1980/90 - 2080/99



Expected Impact of climate change on South America

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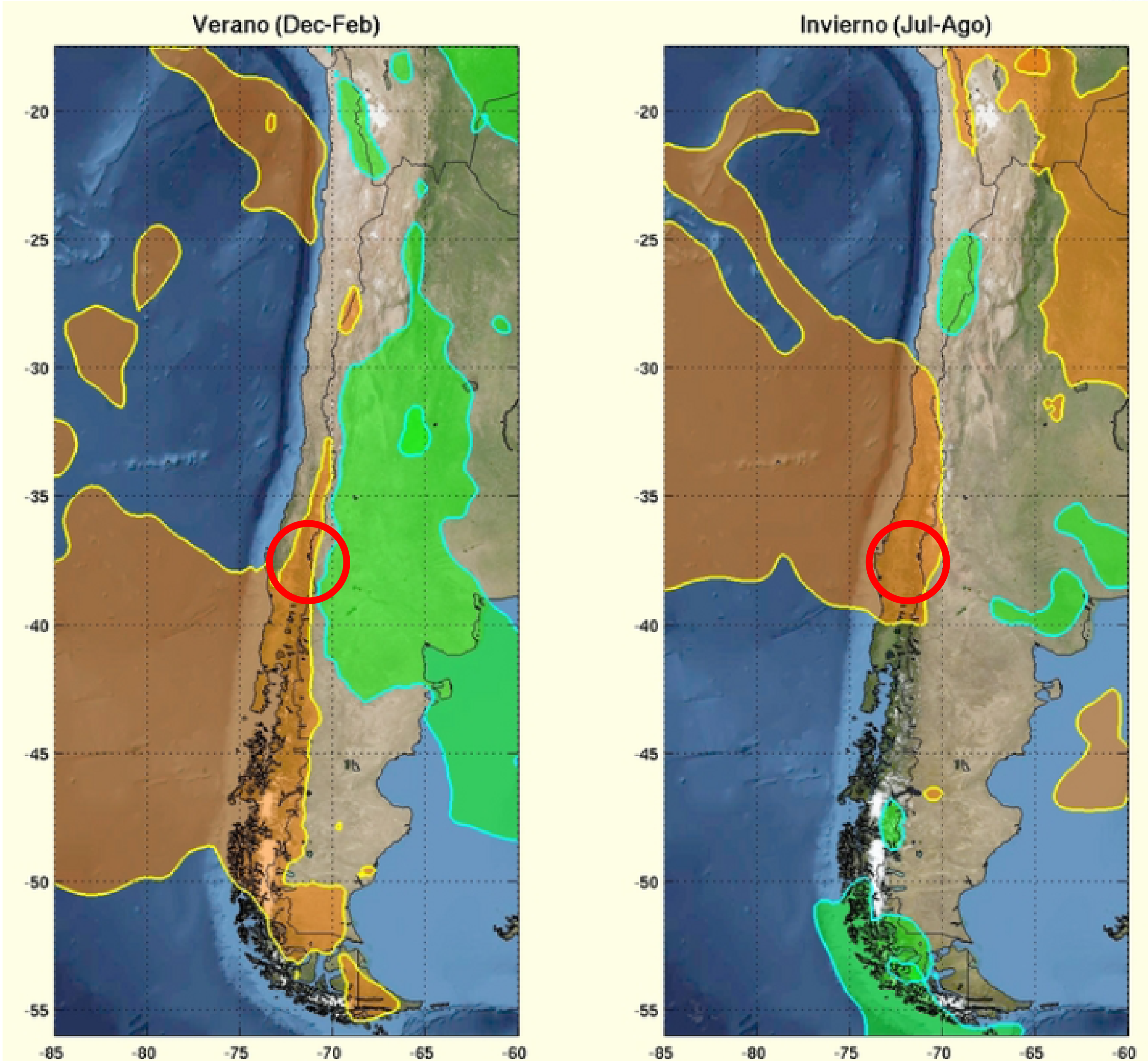
Rainfall w/r to current level (A2) 2040-2050

Reduction above15%

Increases above 15%



Comisión Nacional del Medio Ambiente
(CONAMA)

ESTUDIO DE LA VARIABILIDAD CLIMÁTICA
EN CHILE PARA EL SIGLO XXI

INFORME FINAL
Texto

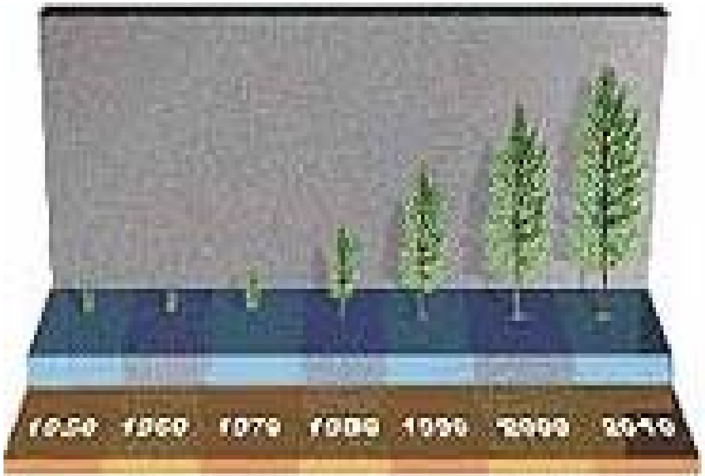
Realizado por: Departamento de Geofísica
Facultad de Ciencias. Físicas y Matemáticas
Universidad de Chile

dgf

Diciembre 2006

Forestry Sector in Chile

3% Chilean GNP
Employment 100.000 people



Forestry Plantations $2.5 \cdot 10^6$ ha

Native Forests 13 million ha

[Highly integrated sector]

Most biomass residues are used as raw material or energy feedstock in plants.

Main Products:

Cellulose

Timber

Chips

Saw wood

Fiberboards

Furniture

Fuelwood

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Forestry Plantations For Industrial Use

Pine :

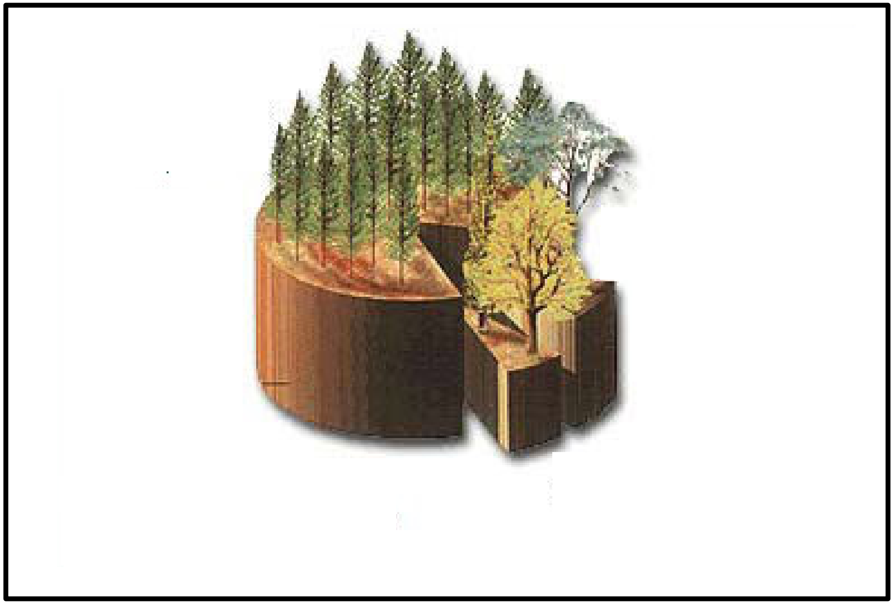
- Timber, Saw wood
- Wood based panels (boards, MDF, plywood)
- Pulp (bleached kraft cellulose)

Eucalyptus:

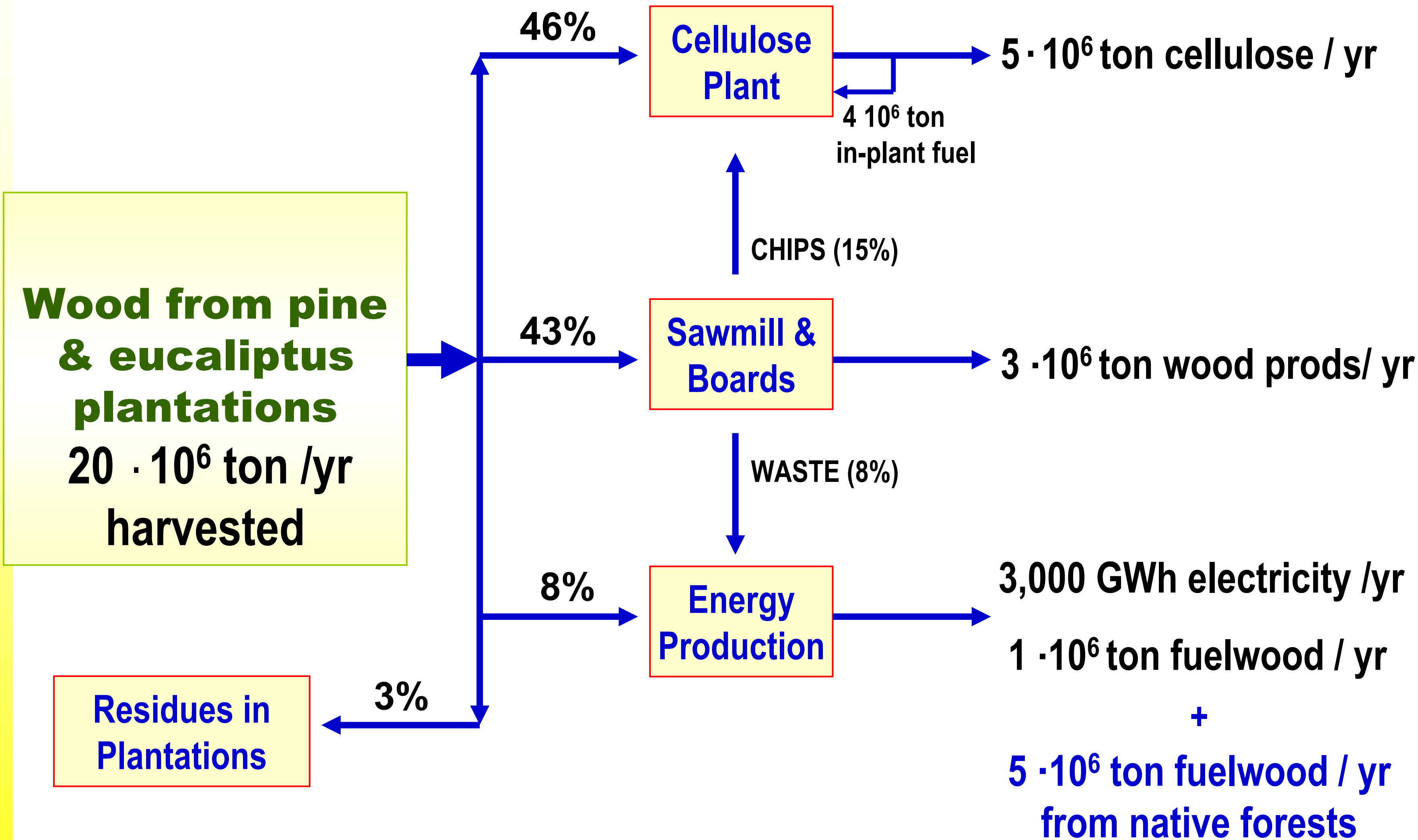
- Pulp (bleached kraft cellulose)

Forestry Plantations 2.5 million ha

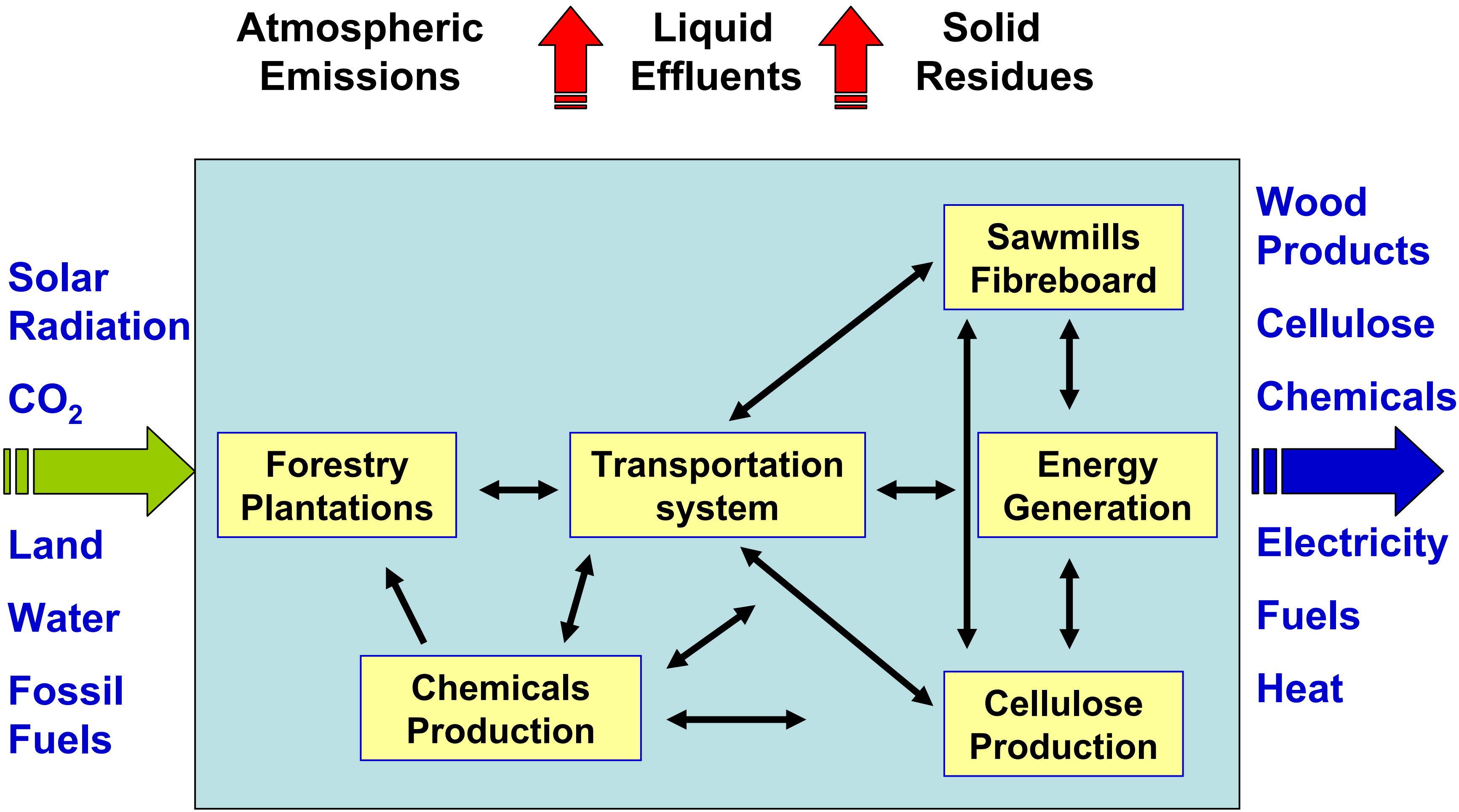
Native Forests 13 million ha



FORESTRY SECTOR MASS BALANCE



FORESTRY INDUSTRY LIFE CYCLE



$2.5 \cdot 10^6$ ha ; 200,000 ton fossil fuels/ yr; $250 \cdot 10^6 m^3$ water / yr

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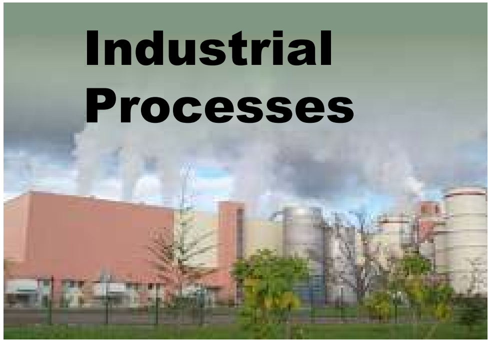
FORESTRY SECTOR AND CARBON BALANCE

$33 \cdot 10^6$ ton CO_2 / year
capture by fotosynthesis

$1 \cdot 10^6$ ton CO_2 / year
from fossil fuels

$18 \cdot 10^6$ ton CO_2 / year
from renewable biomass

CRADDLE – TO – GATE LCI



$14 \cdot 10^6$ ton CO_2 / year net sink

(equivalent to 18% of total CO_2 emissions in Chile)

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FORESTRY PLANTATIONS

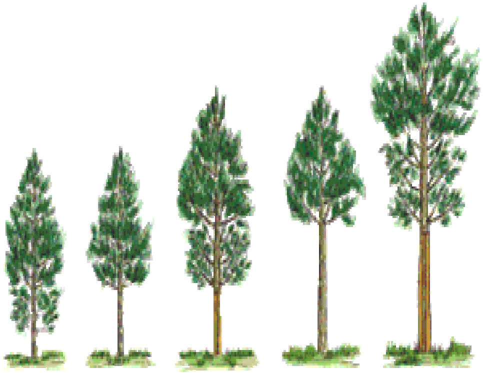
Residues from Pinus radiata plantations

1. Pruning

- Woody residues: 150,000 ton/year

2. Thining

- Woody residues: 100,000 ton/year



3. Harvesting

- Woody residues: 1,000,000 ton/year

Source: *C. Bidart: "Potencialidad de Subproductos Forestales en Chile", Primer Congreso Latinoamericano sobre Biorrefierías, Concepción, Chile, November 21.22, 2007.*

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FORESTRY PLANTATIONS

Residues from Harvesting:

Burnt to reduce volume

Incorporated into the soil

Chipped

Fuelwood

Potential availability for Energy uses

500,000 ton/year forestry residues

Energy from Biomass in Chile

$10 \cdot 10^6$ ha unused / erosion striken land available for forestry activity, mainly in Southern Chile

Government incentives would be required to promote sustainable energy plantations:

- Tax reduction and direct governmental incentives to reforestation.
- Financial and technological support to maximize positive social effects and minimize negative environmental impacts.

Energy from Forestry Biomass

Eucalyptus plantation: yield = 20 ton/ha/year

2,000,000 ha ⇨ 40,000,000 ton/year

ie. 150,000 Tcal / año

3 times current biomass fuels and 35% current coal imports

Native Forests: yield = 5 ton/ha/year

4,000,000 ha ⇨ 20,000,000 ton/year

ie. 75,000 Tcal / año

In total, equiv. to 50% current coal imports and 10% total secondary fuels

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Total Primary Energy Consumption in Chile: : 260.000 Tcal /year (2007)

AGRICULTURE

0.7 % GNP

Total arable land	**700,000 ha**
Wheat and oat crops	**400,000 ha**

Almost all arable land committed to food production (grains, fuits, vegetables)

Little land available for energy crops

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AGRICULTURAL RESIDUES

Agricultural residues 1,500,000 ton/year

Max. Energy potential : 45,000 Tcal / yr

<u>Key problem</u>: transportation costs

(low density, long distances)

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KEY ISSUES

LOGISTIC PROBLEMS:

Urban-industrial centres: Central Chile (30 – 37ºS)

Available land: Southern Chile (40 – 50ºS)

Distances: 400 – 2000 km

Agricultural and Forestry Residues :

Low density materials and high moisture content

Need for decentralised processing, *in-situ* densification or concentration (eg. Bio-oil, charcoal, pellets)

KEY ISSUES

TECHNOLOGICAL CHALLENGES:

- Decentralised processing, *in-situ* densification
- Thermal conversion technologies (pyrolysis, gasification, etc)
- Replacement of old inefficient stoves, for thermally efficient systems for cooking and heating
- Improvement of thermal insulation in construction
- Improvement of specifications of fuelwood
- Efficient environmental control technologies (air pollution control, ash management).

KEY ISSUES

RESEARCH AND DEVELOPMENT ASPECTS:

- **Selection of appropriate lignocellulosic feedstock:**

  - growth rate (m^3 / yr)

  - yield (kJ / ha / yr)

  - energy value (kJ / kg)

  - environmental requirements (T, rainfall, water)

  - chemical composition

- **Appropriate energy conversion / usage technologies.**
  Start from low complexity, and low investment costs.

- **Integration of biomass energy into existing forestry practises and industrial wood processing.**

KEY ISSUES

ENVIRONMENTAL AND SOCIAL MANAGEMENT:

- Prevent reduction of biodiversity and negative impacts on fragile ecosystems.
- Stricter controls on fertiliser use and N_2O emissions.
- Stricter controls on fuelwood specifications. Complex market.
- Policies to favour sustainable native forest management.
- Favour labour intensive systems to maximise impact on rural employment. Adapt labour legislation as required.
- Financial support to small entrepreneurs, to achieve greater local social impacts.

CONCLUSIONS

Need for greater diversity of energy sources, to reduce imported fuel supply/price risks and vulnerability of hydro-electric resources.

Fast growing forestry plantations favour the use of biomass for energy production purposes.

Economic incentives are required to support the settlement of energy plantations. CDM?

Need to improve energy conversion / use technologies and practises.

Social and environmental issues have to be taken into consideration in the design of energy policies.

"The Stone-Age did not end because of lack of stone,

and the Oil Age will end long before the world runs out of oil"

Sheik Zaki Yamani , Former Saudi Arabia Oil Minister,
cited by M. Kircher at Bio-raffiniert V (Oberhausen, 25 March 2009)

THANK YOU VERY MUCH !