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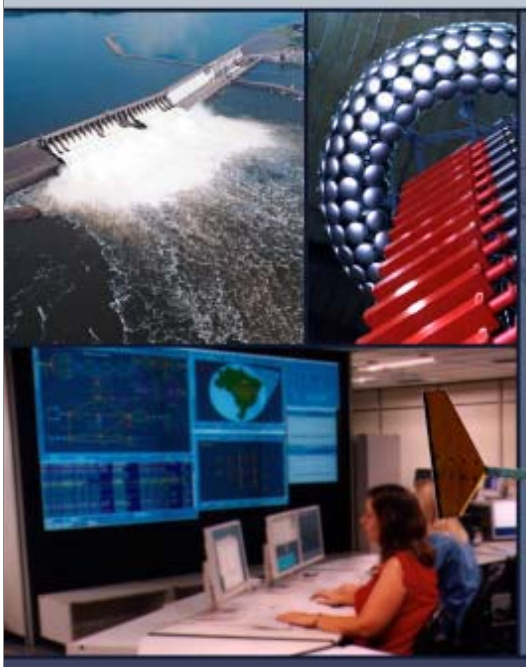


Renewable Energies:
Considerations on environmental impacts and possible applications

I Brazilian Workshop on GC

Fortaleza

November 2007

www.cresesb.cepel.br

I – Introduction

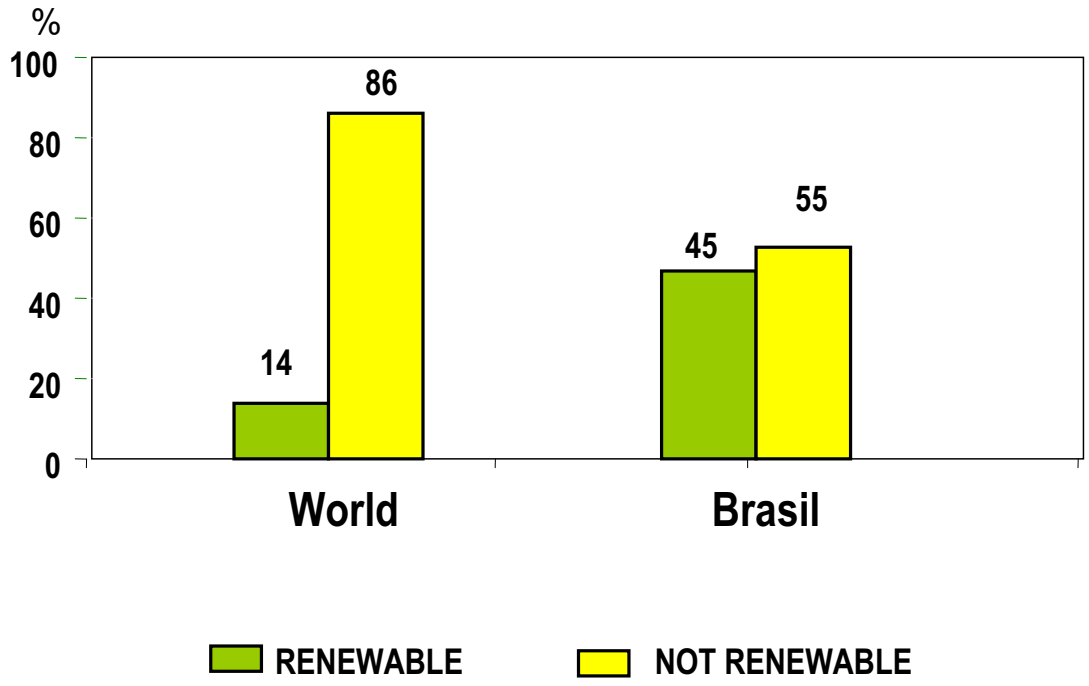
• RE in the framework of the Brazilian Energy Mix and concern with the global heating

II - New Renewables: characteristics and applications

• Solar, Wind, Biomass, Small Hydro

III – Conclusions

I – Introduction



Electrical Mix

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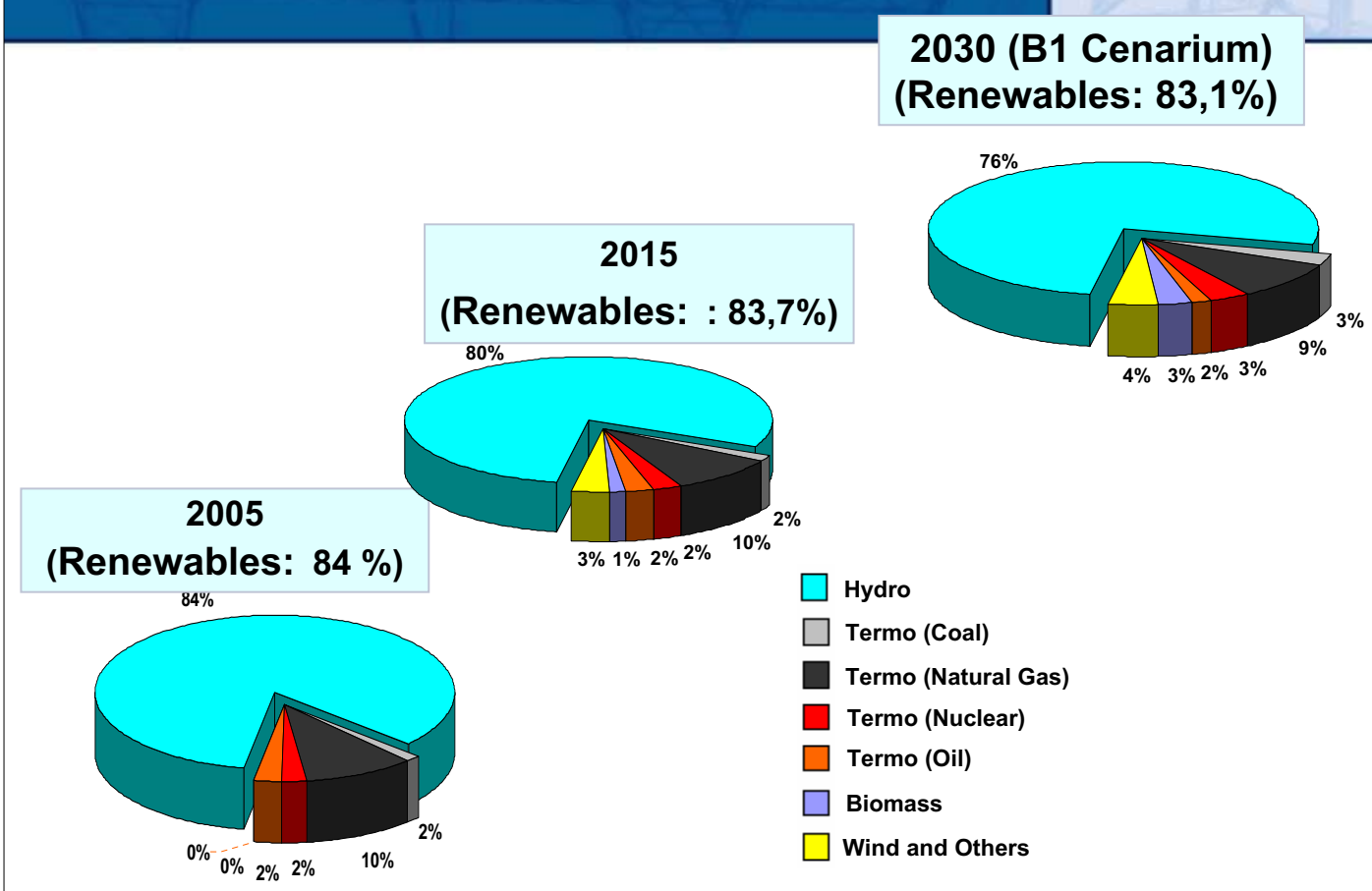
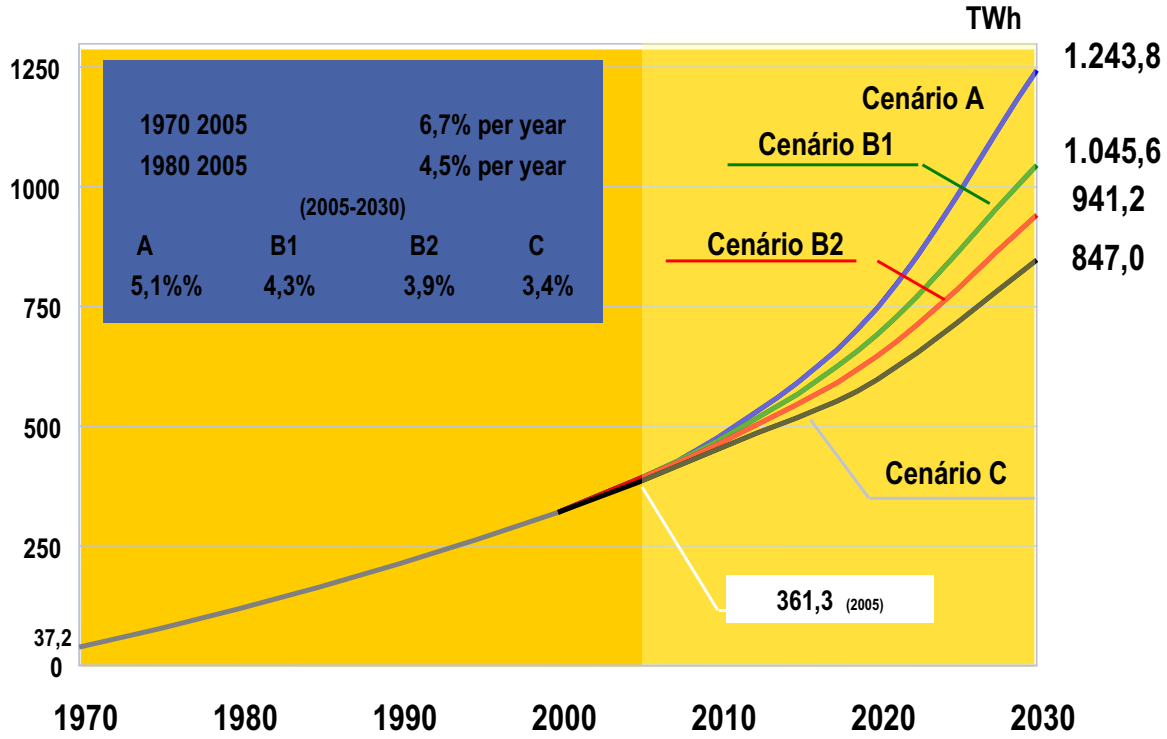
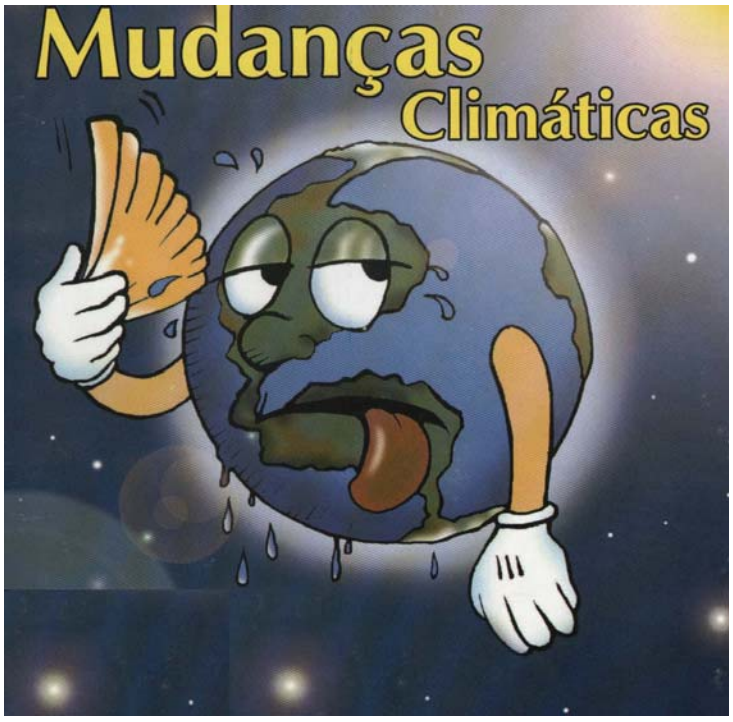


Eletricity: projection of consumption increase



Global Heating



Source: Instituto de Pesquisa ambiental da Amazônia

CO2 Emission of Diverse Technologies (ton/GWh)

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Coal (conventional plant)	1000
Gas	500
Wind	7
PV (Photovoltaic)	5
Large Hydro	4
Solar Thermal	3
Biomass	-160

Externality Costs* (dolar cents per kWh)

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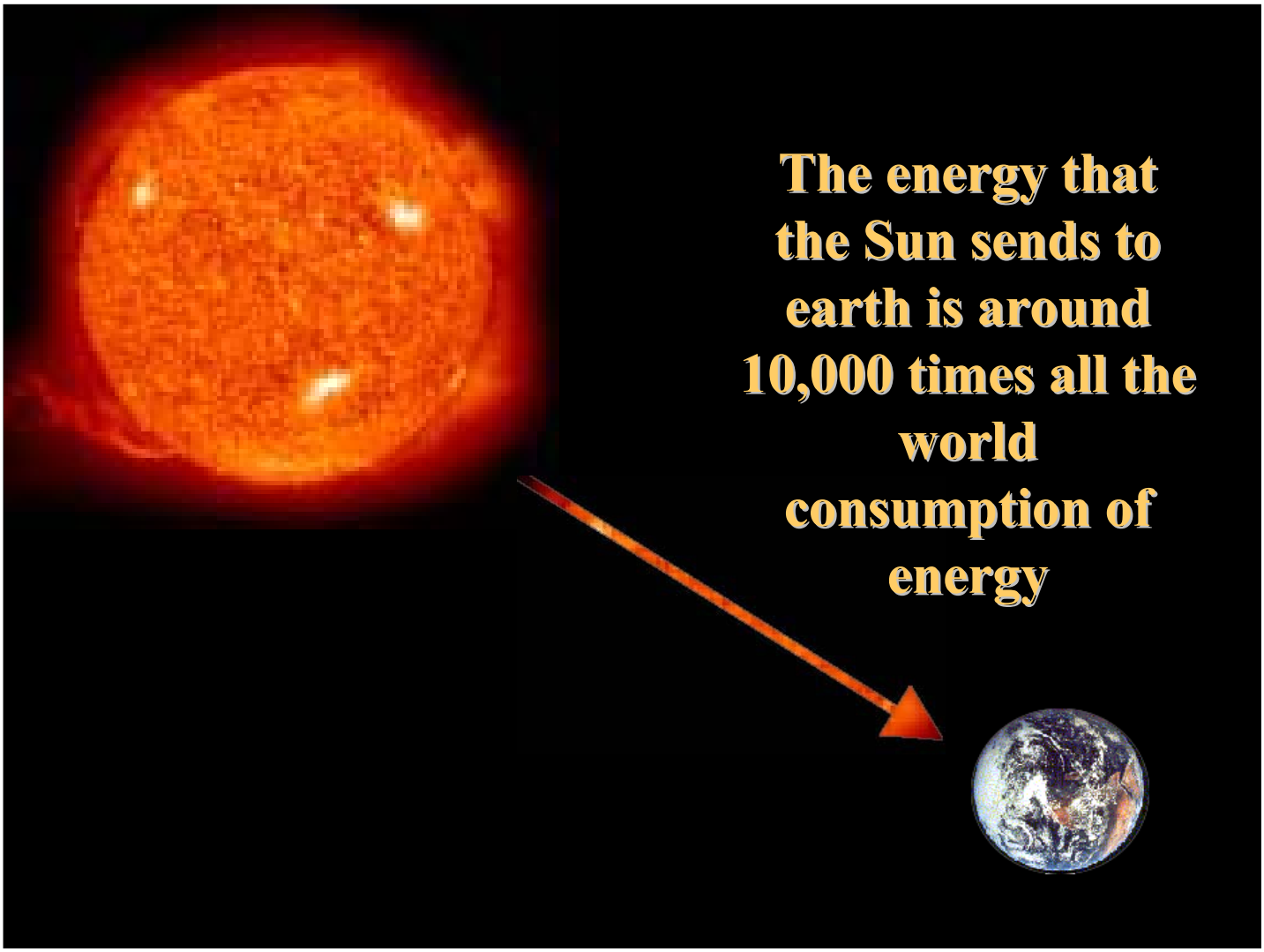
Coal:	1,94 a 14,60
Gas Turbine:	0,97 a 3,89
Nuclear:	0,19 a 0,58
Wind Farm:	0,05 a 0,24

•Cost estimation for the society and for the environment due to the use of fossil and nuclear fuels

EU Study, ExtermE - WSJ - 2002



Global Solar Radiation

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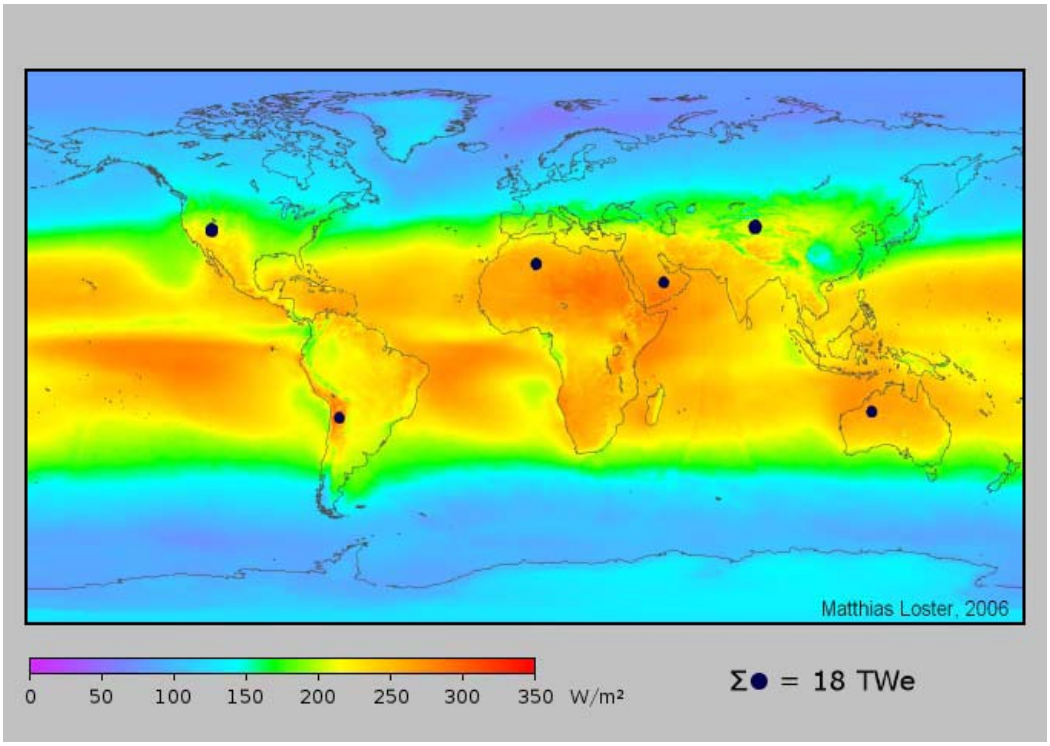
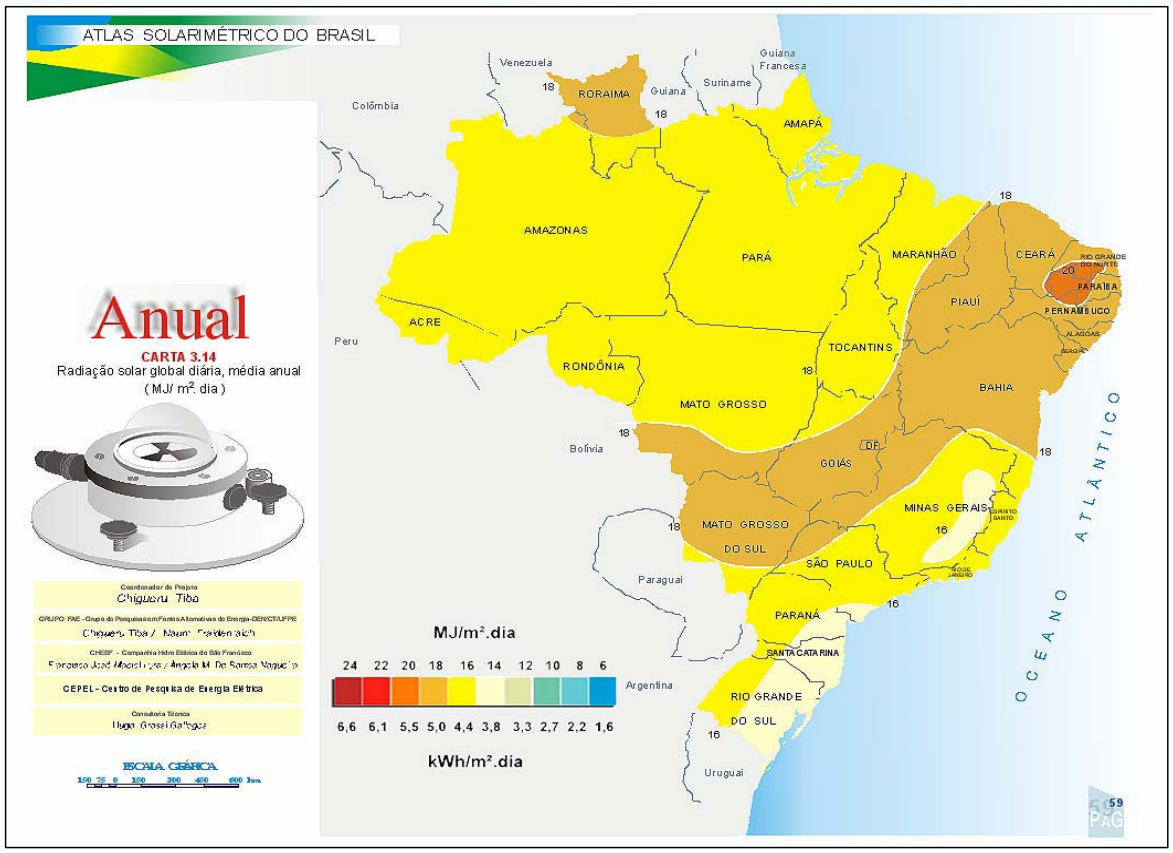


Fonte: Wikipedia

Average Annual Solar Radiation



II – New Renewables

Main Renewable Sources

- Solar Photovoltaic
- Solar Thermal
- Wind
- Biomass
- Small Hydro

Others: Geothermal, Waves, Fuel Cells, etc

Costs and State of the art

TECNOLOGIA		POTENCIAL (GW)	TAMANHO TÍPICO (KW)	APLICAÇÃO	MATURIDADE DA TECNOLOGIA	VIABILIDADE TÉCNICA	CUSTO INVESTIMENTO (US$/KW)	CUSTO O&M (US$/MWh)	CUSTO COMBUSTÍVEL (US$/MWh)	CUSTO GERAÇÃO (US$/MWh)	EFICIÊNCIA
SOLAR FOTOVOLTAICA		-	0.05 A 10	- INTERMITENTE - GRID E OFF-GRID	DEMONSTRADA (GRID) COMERCIAL (OFF-GRID)	MÉDIA (GRID) ALTA (OFF-GRID)	4.000 a 9.000	4 a 20	0.	250 a 500	10 a 18
HELIOTÉRMICA	TORRE CENTRAL	-	30.000 A 200.000	- BASE - GRID	PRÉ COMERCIAL	ALTA	1.000 a 4.800	4 a 23	0.	100 a 250	15 a 30
	CILINDROS	-	50.000	- BASE - GRID	COMERCIAL	ALTA	2.600 a 5.000	4 a 23	0.	130 a 250	15 a 30
	DISCOS	-	20 a 50	- BASE -GRID E OFF-GRID	DEMONSTRADA	MÉDIA	800 a 5.100	15 a 23	0.	100 a 250	15 a 30
EÓLICA		30	300 a 2000	-INTERMITENTE -GRID E OFF-GRID	COMERCIAL	ALTA	700 a 1.200	4 a 12	0.	35 a 120	25 a 45
BIOMASSA		27.7	10 a 50.000	-BASE -GRID E OFF-GRID	COMERCIAL	ALTA	500 a 2.500	6 a 12	20 a 100	38 a 78	25 a 35
PCH's			50 A 1.000	-VARIÁVEL -GRID E OFF-GRID	COMERCIAL	ALTA	1.000 a 3.000	6 a 15	0.	35 a 102	60 a 85

Main Renewable Sources

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→ **Solar Photovoltaic**

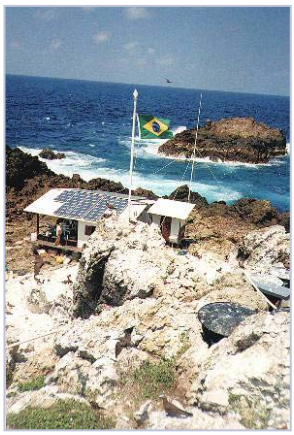
Solar Thermal

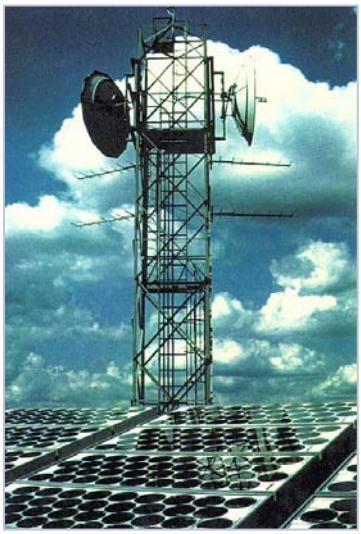
Wind

Biomass

Small Hydro

Others: Geothermal, Waves, Fuel Cells, etc

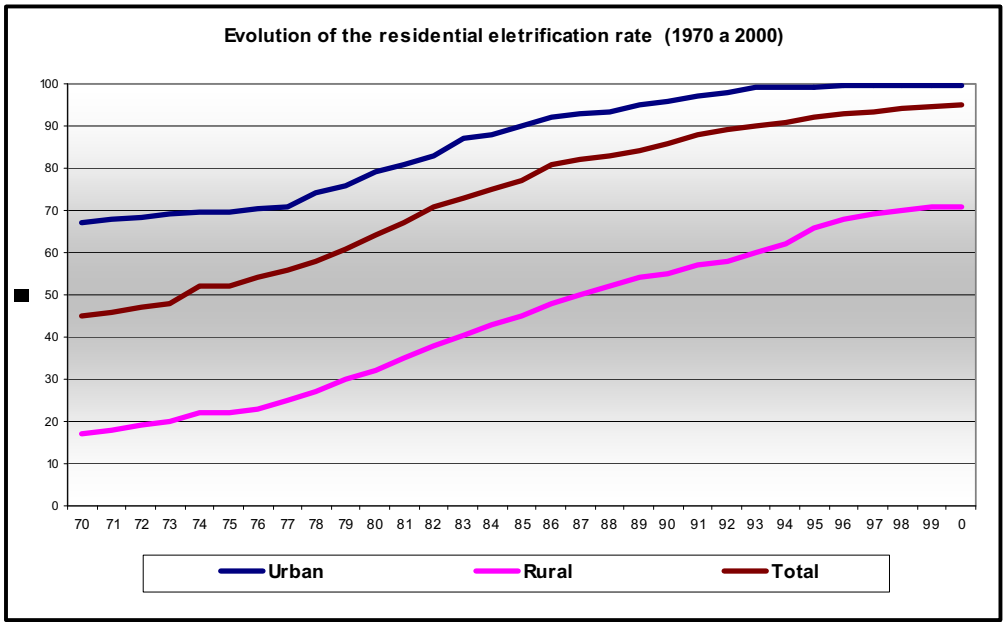




PV – Grid Connected

PV Neurather See (Alemanha) 360kWp

Universalization: chalenges



Source: CEPEL-DTE Report - 211035/2003 - giannini@cepel.br

Main Renewable Sources

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Solar Photovoltaic

→ **Solar Thermal**

Wind

Biomass

Small Hydro

Others: Geothermal, Waves, Fuel Cells, etc

Solar Heating

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Direct Conversion of Solar Radiation

Dishes

Cilinders

Direct Conversion of Solar Radiation

Central Tower

Main Renewable Sources

Solar Photovoltaic

Solar Thermal

→ **Wind**

Biomass

Small Hydro

Others: Geothermal, Waves, Fuel Cells, etc

Wind Energy Applications – Electricity Generation

Small Size (≤10 kW)
- Residential
- Farms
- Remote Applications

Intermediate Size (10- 500 kW)
- Hybrid Systems
- Distributed Generation

Large Size (500 kW - 2+MW)
- Wind Farms
- Distributed Generation

Wind Energy Applications – Electricity Generation

- High quality wind turbines technologicaly developed and produced in Brazil in commercial scale
- Clientes are not grid connected
- Complete system of 1 kW: R$12.000,00
- Complete system of 5 kW: R$ 45.000,00
- System of 10 kW: under development

Intermediate Size (10- 500 kW)

- Hybrid Systems
- Distributed Generation

A promissing feasibility study (preliminary results)

- Costumer: Hospital supplied by the grid
- Load: 380 kW
- Monthly Average Demand:
  - Peak: 345,5 kW
  - Out of Peak: 335,9 kW

A promissing feasibility study (preliminary results)

- Proposed alternative supply:
  - Wind turbine and grid (peak and out of peak)
  - Diesel Generator as back up in peak hours with no wind
- Total investment: R$ 2.536.410,00
- Yearly Savings: **R$ 423.076,63**

A promissing feasibility study (preliminary results)

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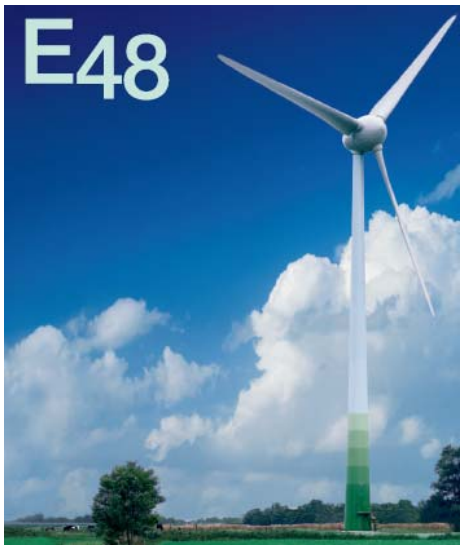
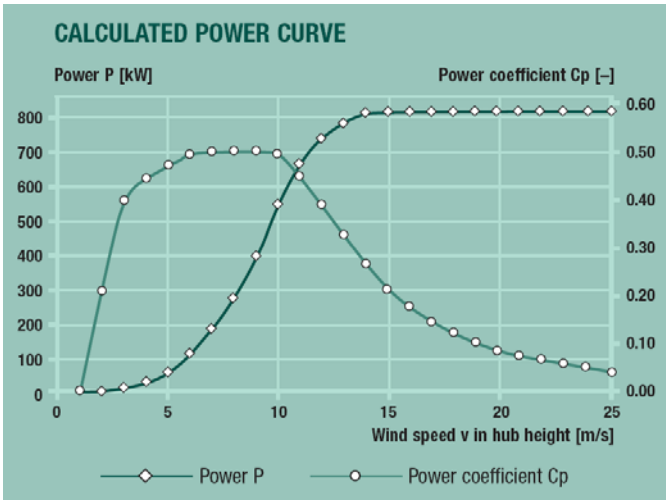
- **Wind turbine considered**





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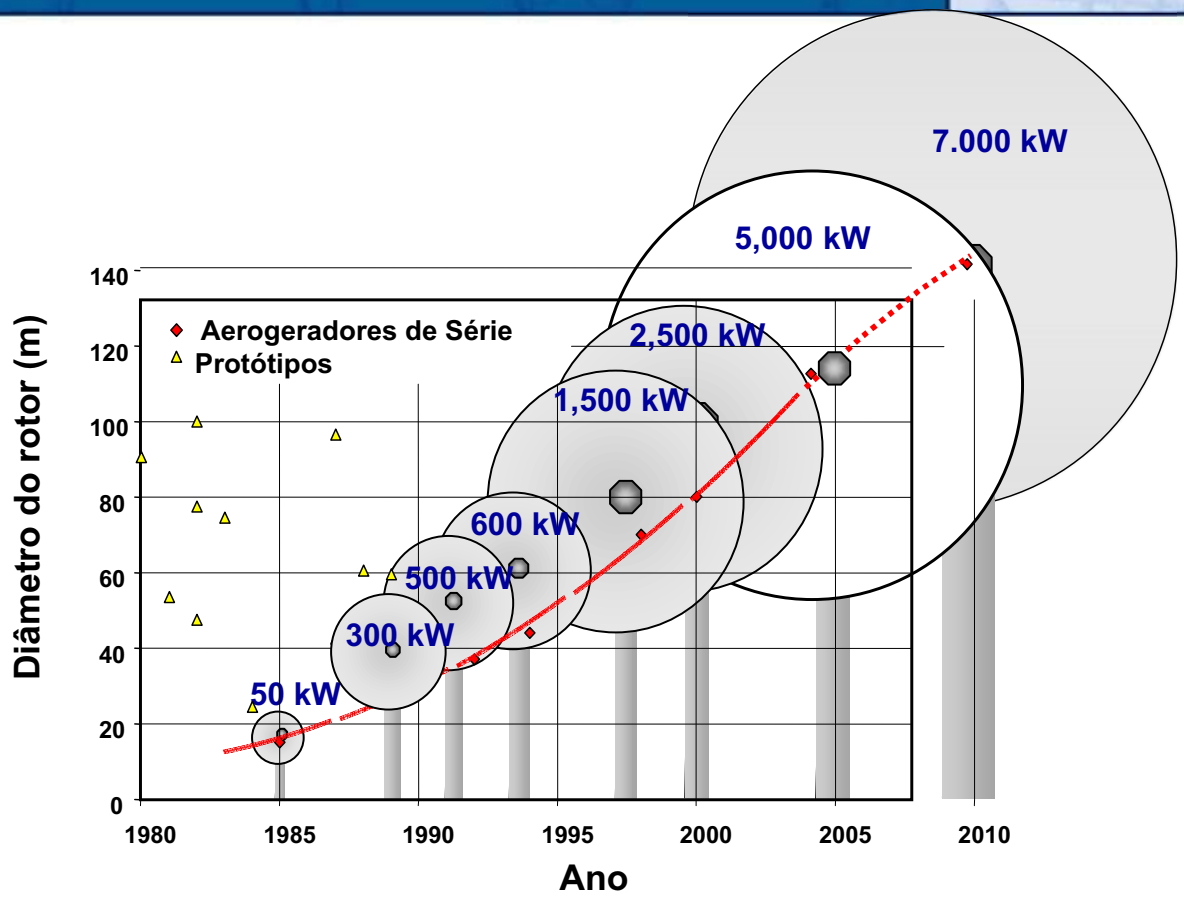
Large Size (500 kW - 2+MW)

- Wind Farms
- Distributed Generation

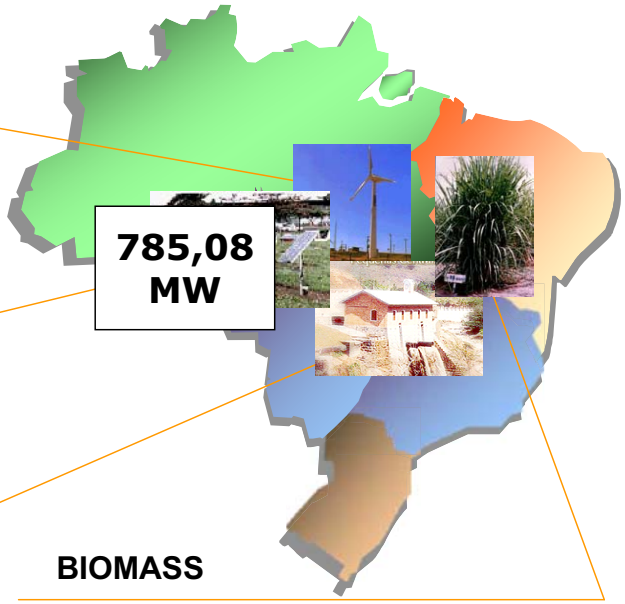


PROINFA
Electric Energy Alternative Sources Incentive Program

Wind: 208,3 MW

5 wind farms

December 2006



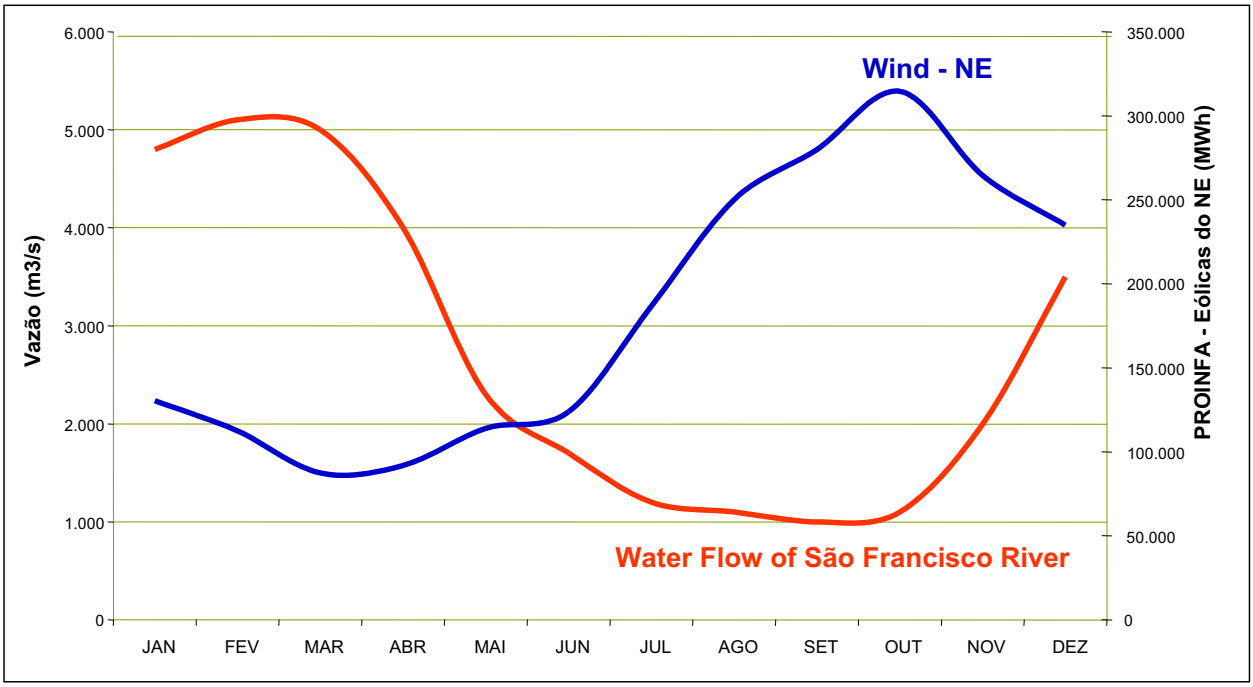
PCH

162,34 MW

BIOMASS

414,44 MW

(Fonte: EMME,2007)



- **It is not feasible, with the present technology, to store large amounts of energy generated by an intermitent source of energy as the wind.**

- **The combined utilization of Hydro and Wind, improves the energetic potential of both sources due to the seazonal complementary characteristics of them.**

Wind Atlas

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Wind Atlas

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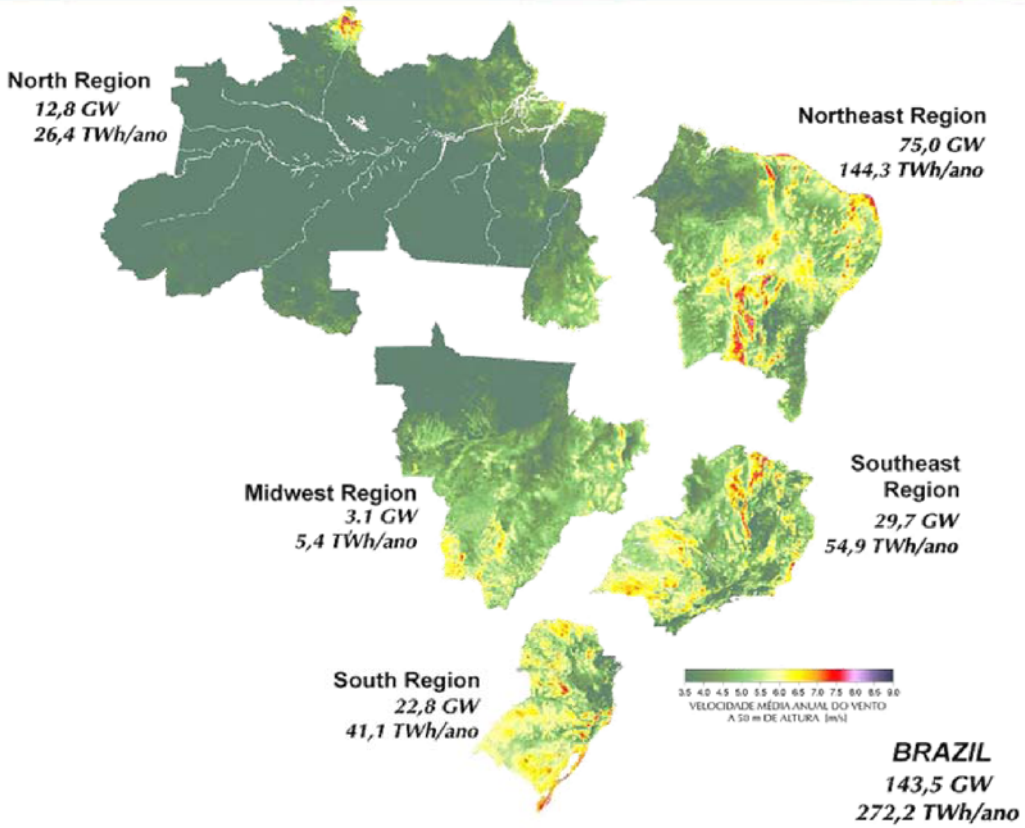

Substituindo Usina Nuclear por Energia Solar Fotovoltaica e Energia Eólica
Áreas Equivalentes Necessárias – 10 TWh/ano

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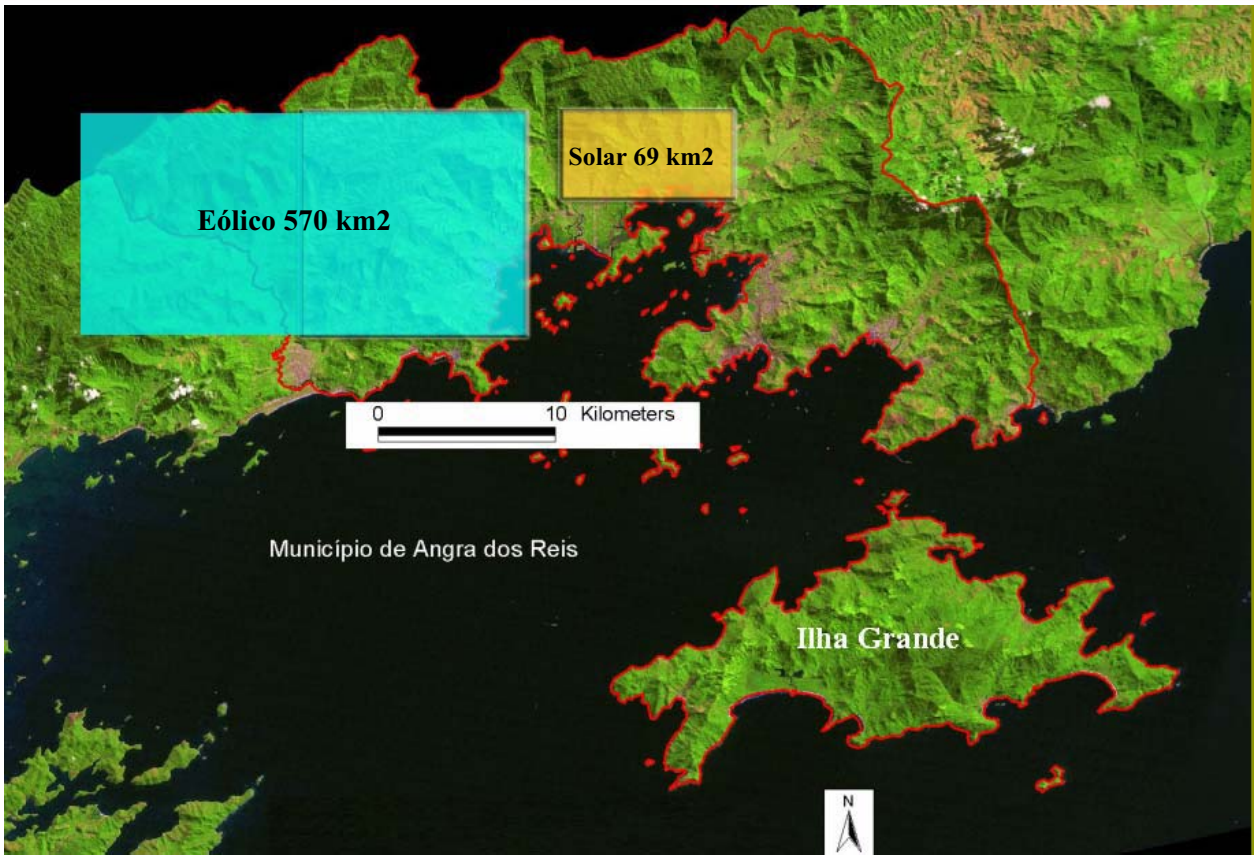

Main Renewable Sources

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Solar Photovoltaic

Solar Thermal

Wind

→ **Biomass**

Small Hydro

Others: Geothermal, Waves, Fuel Cells, etc

Biomass

Biomass: Energy and Materials

Main Renewable Sources

Solar Photovoltaic

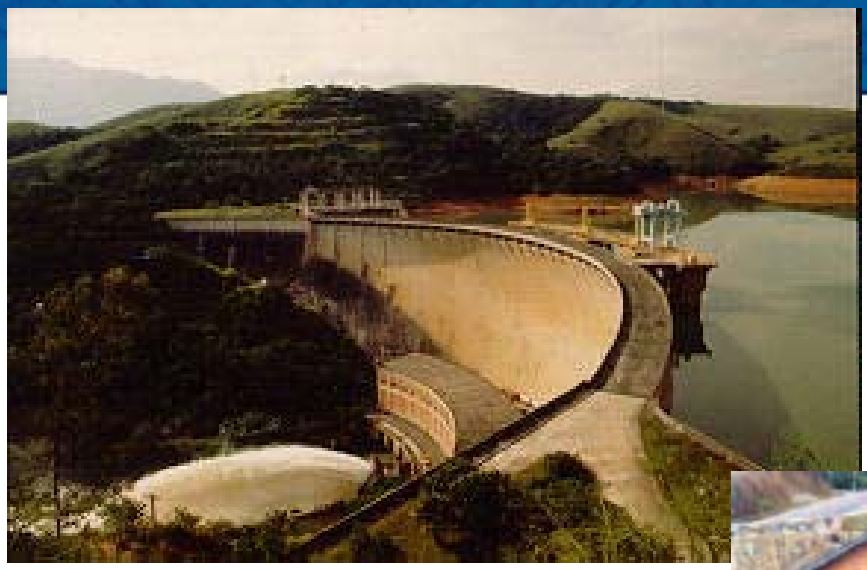
Solar Thermal

Wind

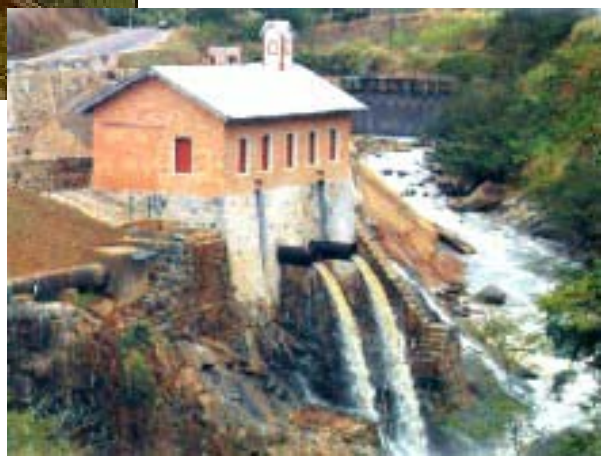
Biomass

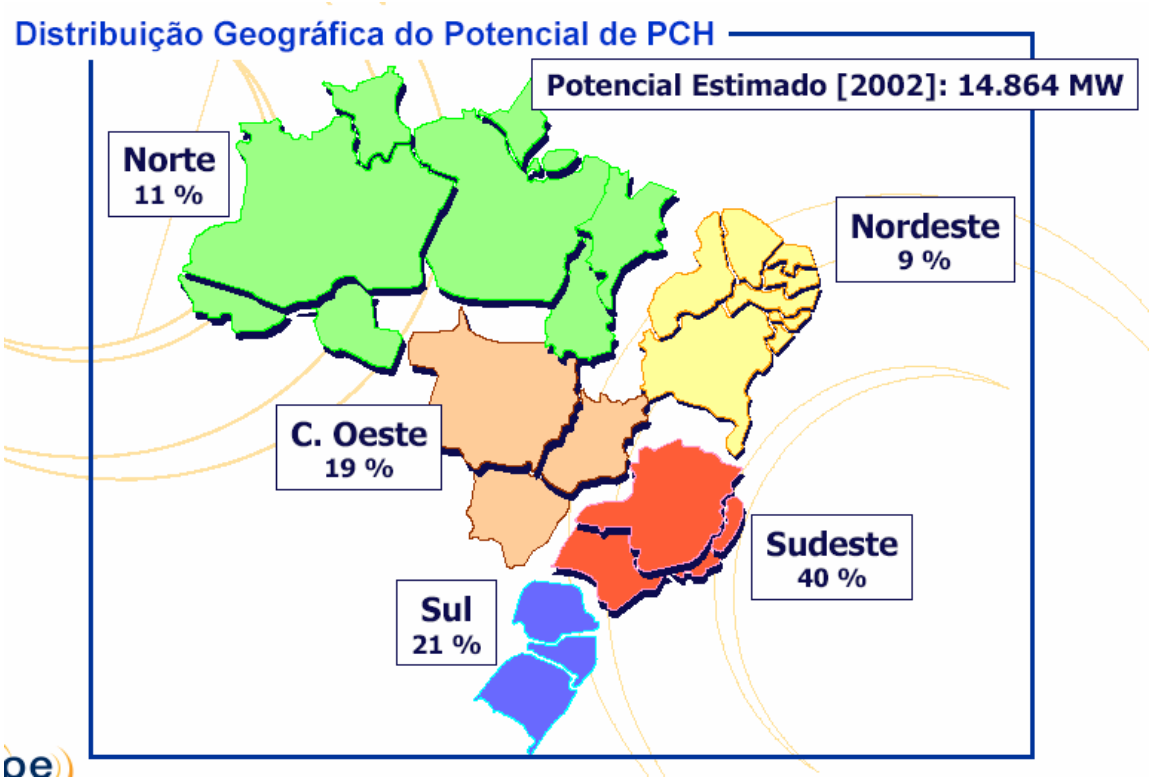
→ **Small Hydro**

Others: Geothermal, Waves, Fuel Cells, etc



Small Hydro





Fonte: EPE – Apresentação PNE 2030

III – Conclusions

- **Energy prices for energy generated by some renewable are approaching the prices of conventional sources**

- **With lower prices of equipment, production scale, with better natural source characteristics than previous expected and the growing concern with environmental impacts, the penetration of renewable energies can be higher than conservative nowadays forecast.**

- **Intermediate and small systems can be economically feasible in specific applications even with the present price conditions.**

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