The Brazilian Energy Matrix and Greenhouse Gas Emissions

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CO_2 Emissions from Fossil Fuels

Brazil and Some Emerging and OECD Countries - 1995

	Brazil	Japan	Europ Union	USA	Mexic o	India	China	Russia
CO_2 & economy *(kg CO_2/US$_{90}$GDP$_{PPP}$)*	0.33	0.46	0.51	0.85	0.51	0.73	0.92	2.24
CO_2 per capita *(t CO_2/hab)*	1.81	9.17	8.55	19.88	3.46	0.86	2.51	10.44
Total CO_2 *(million t CO_2)*	287	1151	3180	5229	328	803	3007	1548
Transport Emissions *(million t CO_2)*	119	252	828	1580	101	112	167	108
Share of Transport *(%)*	41.5	21.9	26.0	30.2	30.8	13.9	5.6	7.0

Source: International Energy Agency, *CO2 Emissions from Fossil Fuel Combustion: 1972-1995*. OECD, Paris, 1997

Hydro

- Power generation contributes with just 5% of the total CO_2 energy emissions in Brazil.
- OCDE – 30% of emissions
- if the “mix” were 50% hydro, 25% coal and 25% natural gas combined cycle
  - the avoided emissions would be on the order of 30 million tC in 1996.
- more or less 1/3 of the Brazilian emissions in that year.

Alcohol from Sugarcane

- The production and use of ethanol as the sole fuel or mixed with gasoline reduces current emissions by an estimated 9 million t C
- In the late 80s, alcohol vehicles accounted for 90% of total sales –
- a fleet of 5 million alcohol vehicles circulated in Brazil.
- Today– less than 0,5% of new car sales.

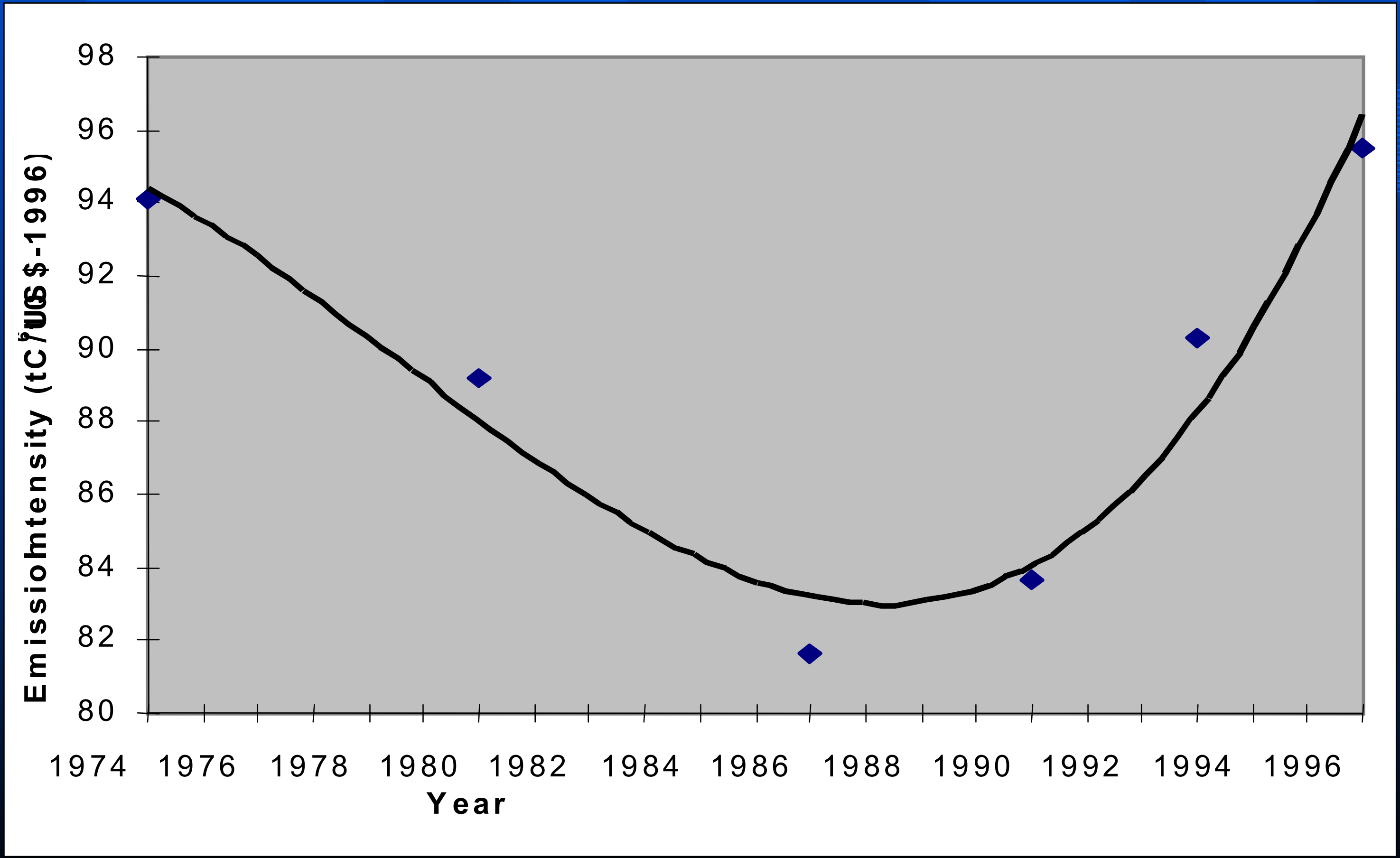
Charcoal

- Brazil is one of the few countries in the world that has kept a significant metallurgical industry based on charcoal
- The current level of use of charcoal avoids an annual emission of more than 3 million t C of CO_2.

Metalurgical Charcoal in Brazil - 1980/96

	1980	1985	1990	1995	1996
Metalurgical charcoal *(10^6 t/year)*	4.9	8.1	8.4	6.8	6.1
Share of planted wood *(%)*	-	15	35	55	-

Emissions of CO_2 from Fossil Fuels per Unit of GDP – Brazil ($tC/10^6$ $US\$_{96}$ GDP)

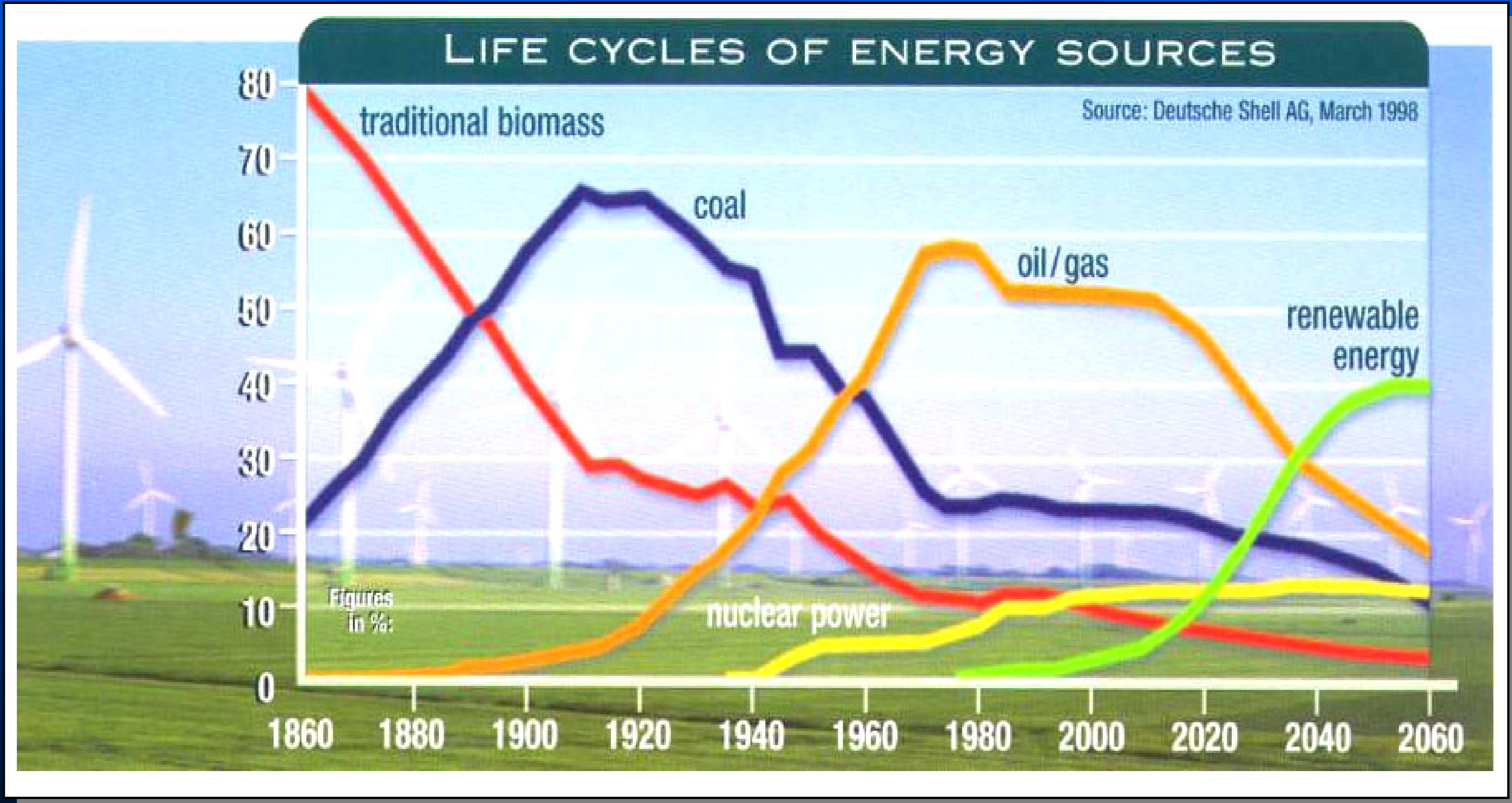


CO_2 Emissions Different Technologies

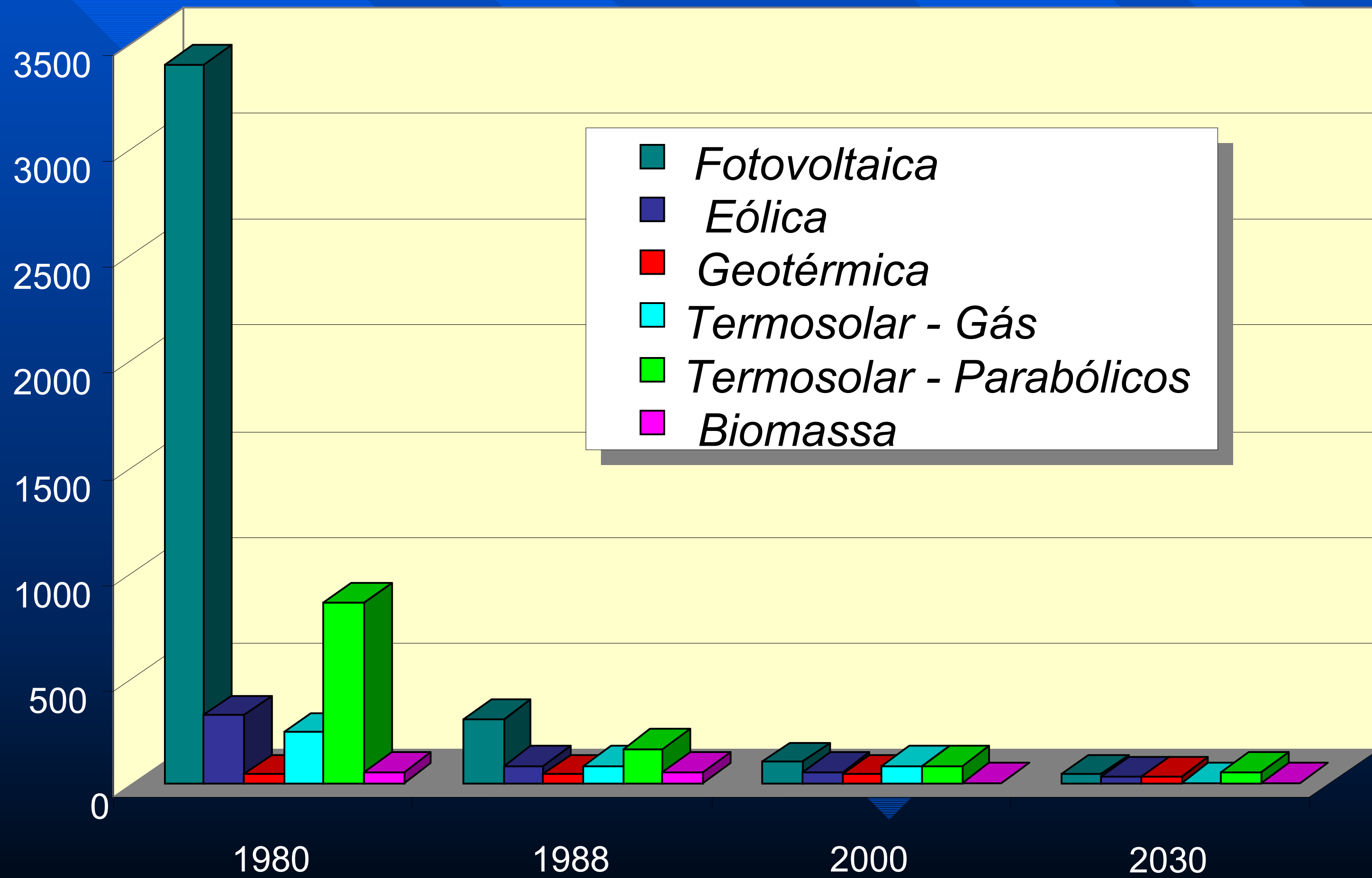
Tecnologias	Emissões de CO_2 nos estágios de produção de energia (ton/GWh)			
	Extração	***Construção***	***Operação***	***Total***
Planta convencional de queima de carvão	1	1	962	964
Planta de queima de gás	0	0	484	484
Pequenas hidrelétricas	-	10	-	10
Energia eólica	-	7	-	7
Solar fotovoltaico	-	5	-	5
Grandes hidrelétricas	-	4	-	4
Solar térmico	-	3	-	3
Lenha (Extração programável)	-1.509	3	1.346	-160

Fonte: "Renewable Energy Resources: Opportunities and Constraints 1990-2020" - World Energy Council - 1993

The Future of Renewable Energy Sources

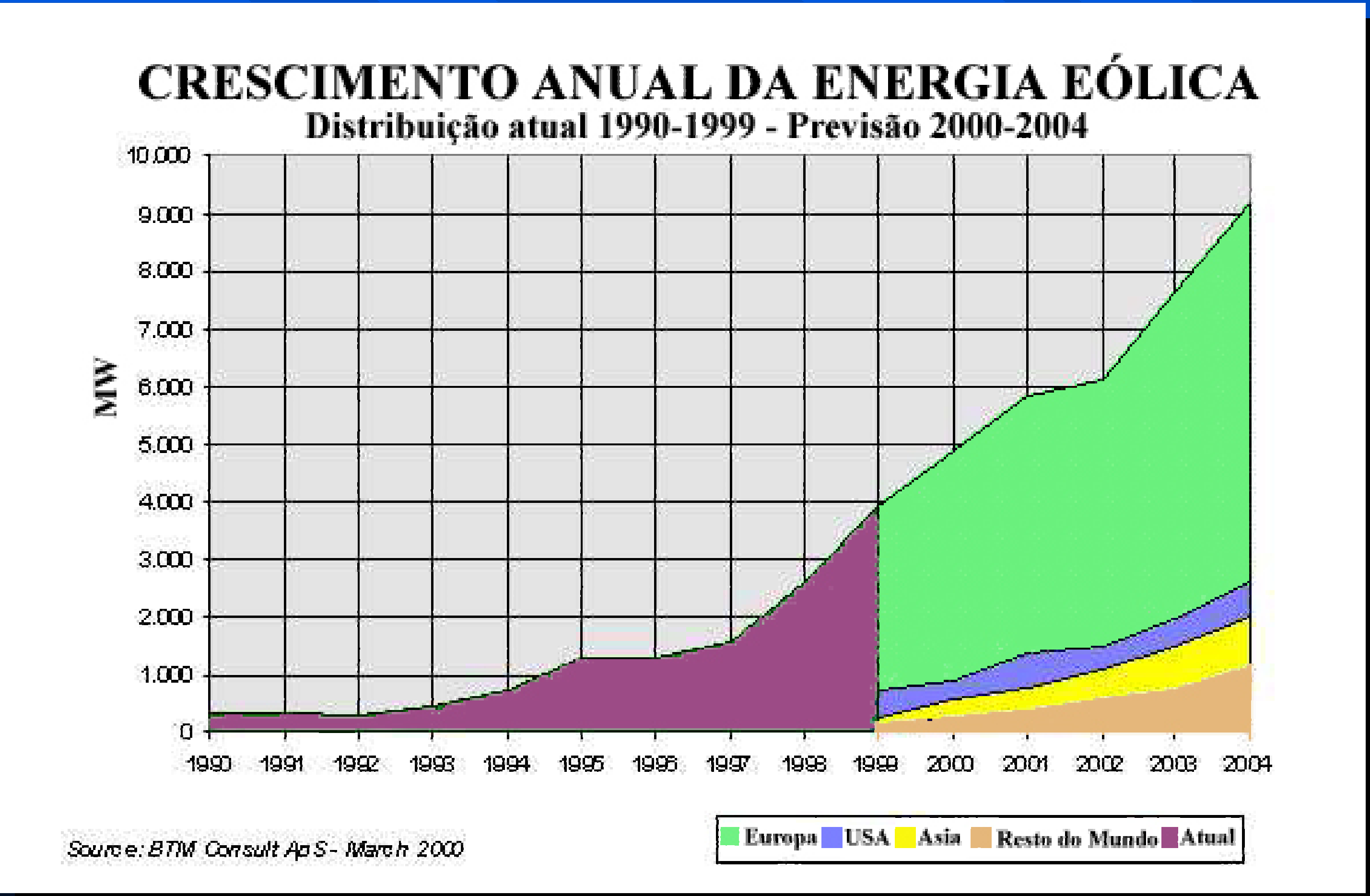


Renewable Energy Costs Evolution (US$/MWh)



Fonte: www.cresesb.cepel.br

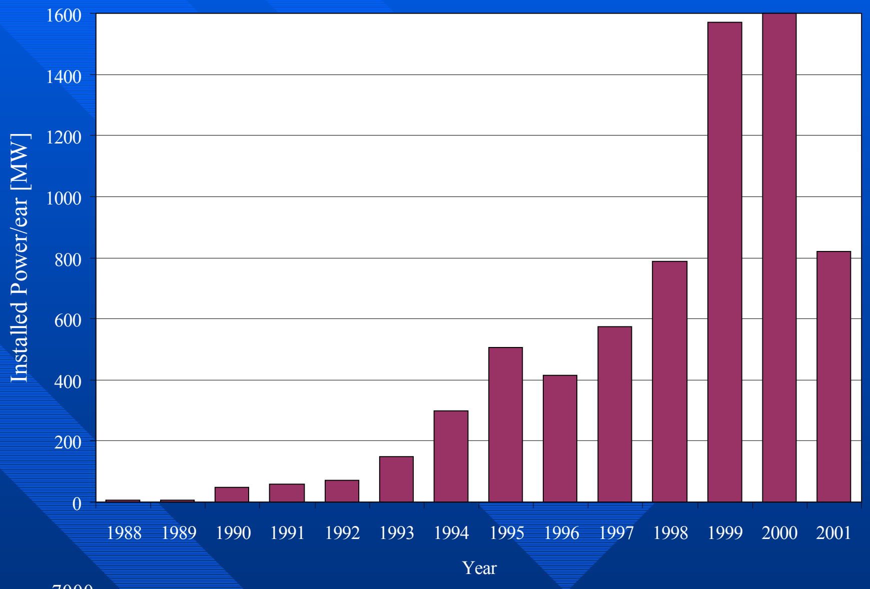
The Future of Wind Energy Forecast until 2004



Wind Energy in German - 2001

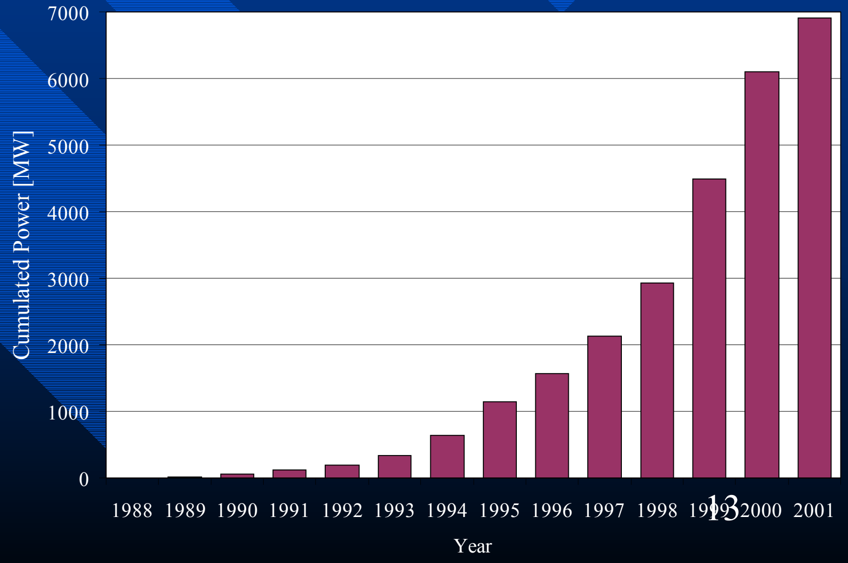
	Cumulated	Only in the first 6 month of 2001
Number of Wind Turbines (in June 2001)	10.033,00	674,00
Installed Capacity (MW)	6.916,00	821,00
Average Rated Power (kW/unit)	689,40	1.219,00

Fonte: DEWI, 2000



$13 * 10^6$ MWh/year (2000)

2% of the German Energy Consumption in 1999

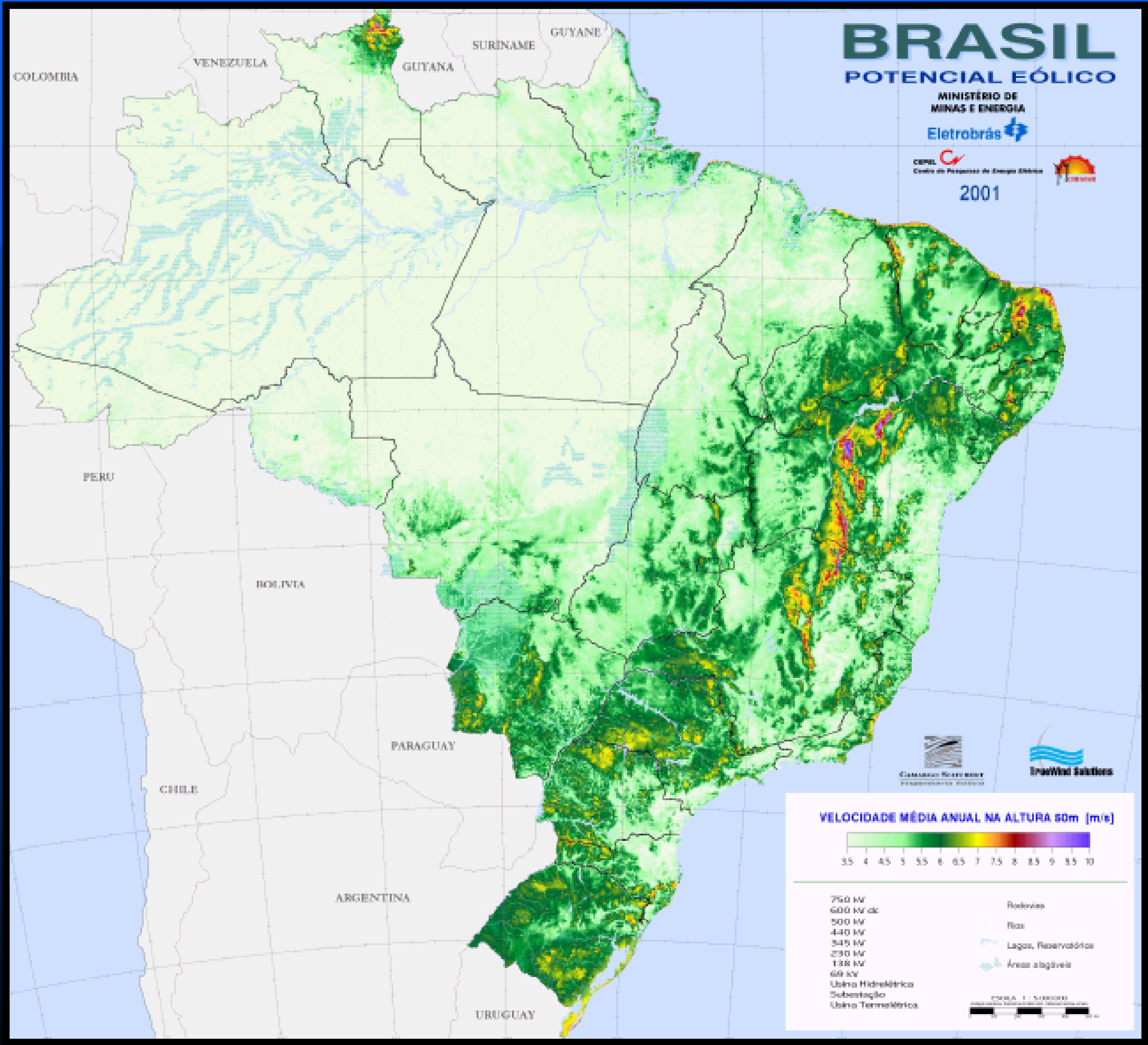


Actual Situation of the Brazilian Wind Energy Use
(Types of Turbines)

Instalação	*Implementação*	*Finaciadores*	*Potência*	*Início de operação*
Projetos em operação				
Fernando de Noronha – PE	CELPE, UFPE/Folkcenter	30% Dinamarca	75 kW	1992
Morro do Camelinho – MG	CEMIG	70% Alemanha	1 MW	1994
Porto de Mucuripe – CE	COELCE	70% Alemanha	1.2 MW	1996
Sist. Híbrido de Joanes – PA	CEPEL/CELPA	100% USA	40 kW	1997
Central Eólica de Prainha – CE	Wobben Windpower/ COELCE	Privado	10 MW	1999
Central Eólica de Taíba – CE	Wobben Windpower /COELCE	Privado	5 MW	1999
Usina de Palmas – PR	Wobben Windpower/COPEL	Privado	2.5 MW	1999

20,3 MW installed

Brazilian Wind Energy Atlas – Preliminary Version 2001



Fonte: www.cresesb.cepel.br

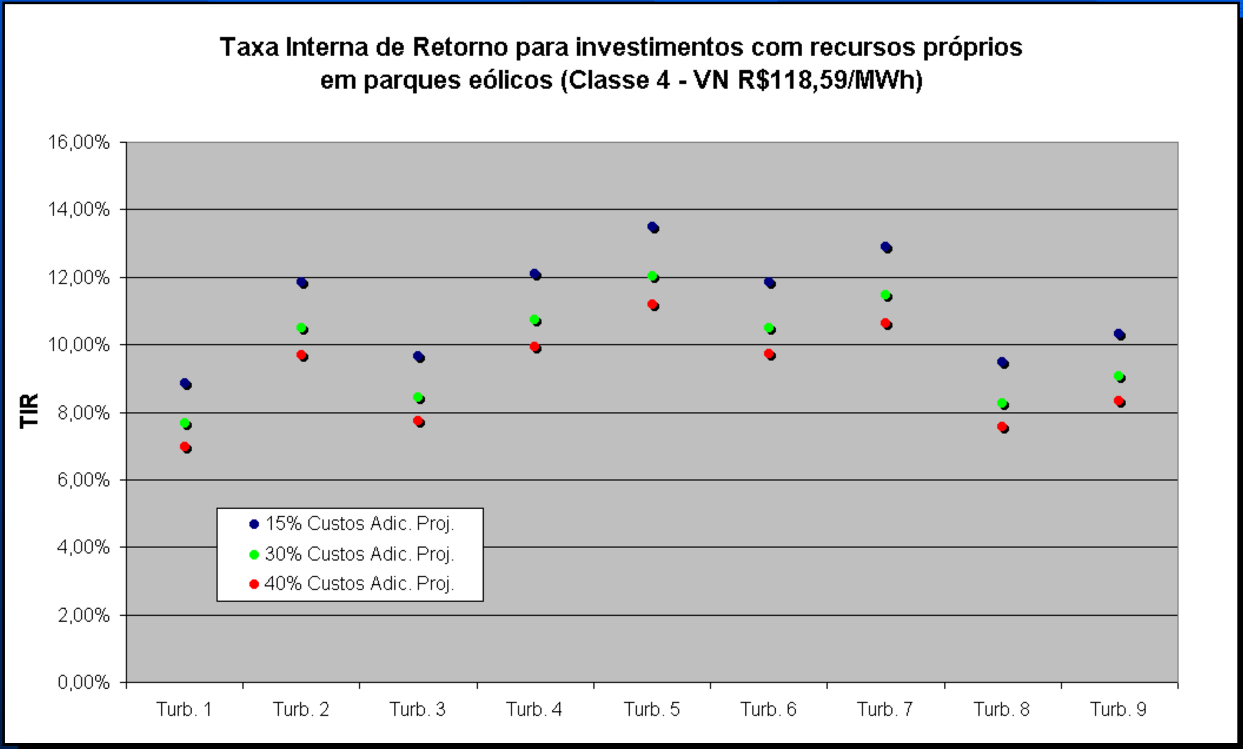
Valor Normativo - Res. ANEEL 22/2001

Fonte	R$/ MWh
Termelétrica a Gás	72,35
Termelétrica Carvão	74,86
Pequena Central Elétrica	79,29
Termelétrica Biomassa	89,86
Usina Eólica	112,21
Usina Solar Fotovoltaica	264,12

Ref. Fev/2001

Economic Evaluation of Wind Energy in Brazil

- own capital -



Fonte: DUTRA, 2001

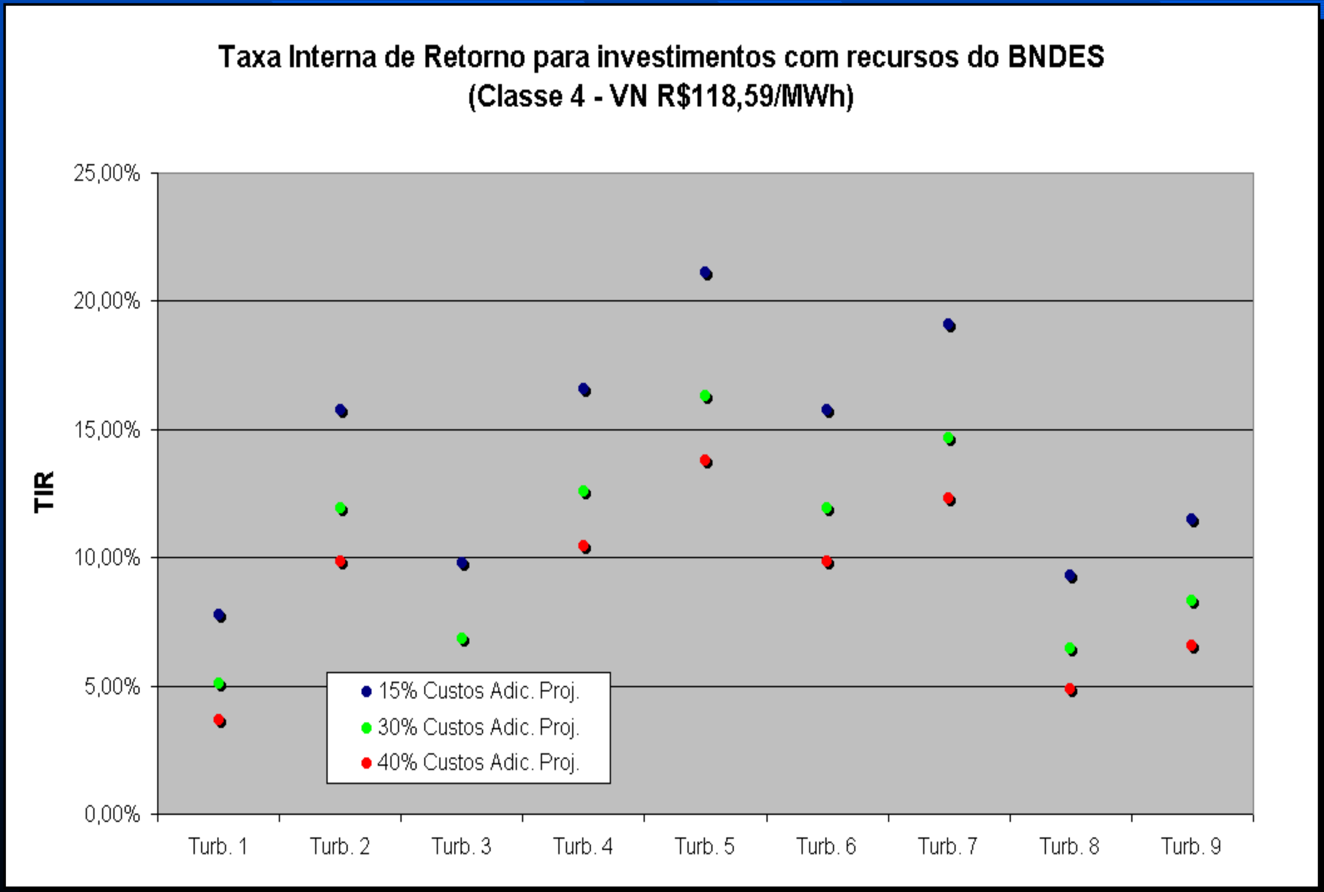
Load Factor 40%

Model	Power
Turbina 1	200 kW
Turbina 2	250 kW
Turbina 3	300 kW
Turbina 4	500 kW
Turbina 5	750 kW
Turbina 6	660 kW
Turbina 7	1300 kW
Turbina 8	1500 kW
Turbina 9	1500 kW

Economic Evaluation of Wind Energy in Brazil

- resources from BNDES - PASE -

PASE – Electrical Power Program



Load Factor 40%

Fonte: DUTRA, 2001

BAGASSE-BASED COGENERATION

Market Percentage for the 2005 Scenario

Technology	Harvesting Method (a)	Associated Biomass Proportion	Available Biomass Distribution by Season (million tons/year)		Forecast (GWh/year)	Forecast (MW) (b,c)
			Harvest	Mid-Harvest		
Current Counter-Pressure Cycle	Without Recovery	60%	52.65	-	3,949	676
Efficiency-Enhanced Counter-Pressure Cycle	With Recovery	40%	56.94	-	12,812	2,194
Condensation and Extraction Cycle	-	0%	-	-	0	0
Biomass Gasification and Combined Cycle	-	0%	-	-	0	0
Total			**109.59**		**16,760**	**2,870**

Without Recovery - straw and tips are burned off before harvesting **With Recovery** - raw sugarcane is mechanically harvested, with a recovery rate of 40% in absolute terms of the straw and tips

Market Percentage for the 2010 Scenario

Technology	Harvesting Method (a)	Associated Biomass Proportion	Available Biomass Distribution by Season (million tons/year)		Forecast (GWh/year)	Forecast (MW) (b,c)
			Harvest	Mid-Harvest		
Current Counter-Pressure Cycle	Without Recovery	30%	28.35	-	2,126	364
Efficiency Enhanced Counter-Pressure Cycle	With Recovery	40%	61.32	-	13,797	2,363
Condensation and Extraction Cycle	With Recovery	15%	14.18	8.82	9,888	1,693
Biomass Gasification and Combined Cycle	With Recovery	15%	14.8	8.82	20,466	3,504
Total			**118.02**		**46,277**	**7,924**

NATURAL GAZ COGENERATION

Reasons to encourage cogeneration

Compared to conventional thermo-power generation:

- • It ensures lowest energy consumption
- • It reduces atmospheric emissions
- • It could serve electricity markets with:
- o lower investments in the transmission and distribution grids and networks
- o with lower energy losses during transmission.
- It may allow the postponement of high-volume investments in expanding centralized power generation capacity.

- However, these reasons have not encouraged investments in cogeneration in Brazil in the past.
- • total cogeneration potential - between 11 and 17 GW
- • technical potential for industrial cogeneration - about 12,499 MW
- the installed capacity of cogeneration systems in Brazil by 2000 did not exceed 2 GW.

Energy policy

- 1. Foster the expansion of cogeneration in segments where investments are not allocated spontaneously, either because:
- • the benefits of cogeneration are not perceived or
- • these benefits are not properly appraised,
  - o investors may be unwilling to channel funds to a sector outside their core activities, or
  - o there may be market barriers to this investment.

Energy policy

- 2. Encourage:
- o the expansion of more efficient cogeneration systems and
- o the conversion of less efficient systems to more efficient levels, resulting in high fuel savings.
  - For instance, this was one of the guidelines of Denmark's (1980s and 1990s) and French (1990s) policy.

Energy policy

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- 3. Encourage rapid expansion of the installed capacity of cogeneration systems.

- For instance, incentives designed to encourage the sale of cogenerated surplus power speeded up the expansion of installed cogeneration capacity in
  - the USA (1980s),
  - Netherlands (early 1990s), and
  - France (end of this decade).

Energy policy

- 4. Encourage the consumption of certain fuels rather than others, due to:
- • either environmental reasons or
- • issues of a technical and economic nature (such as the availability of energy resources).

- This is the case with both
  - the Netherlands and
  - Denmark, (in terms of natural gas and renewable fuel sources).