



Programa de Planejamento Energético
COPPE/UFRJ

Energy Situation in Brazil

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Berlin, 21 June 2012

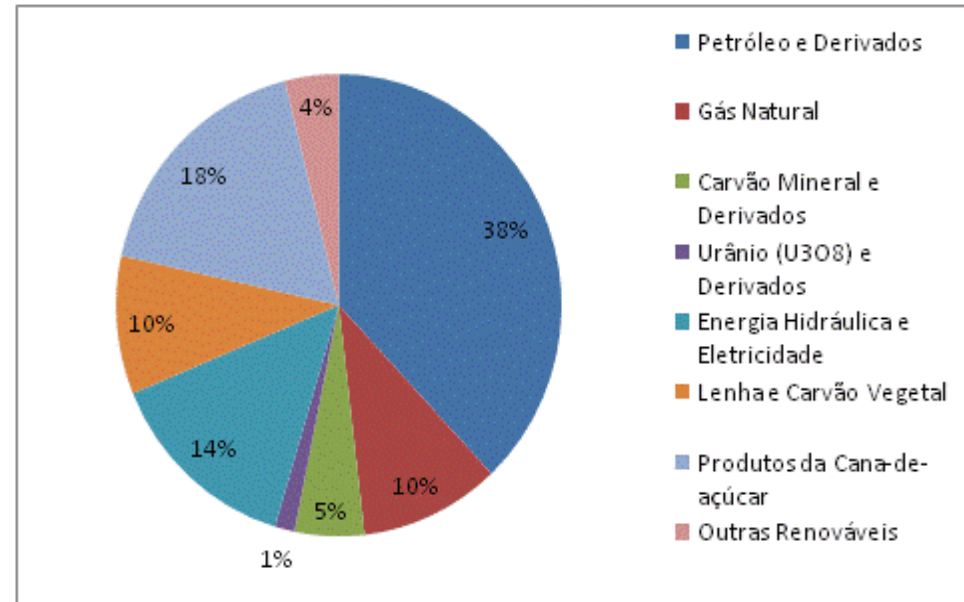
Brazilian Energy Mix

- ◆ Domestic energy supply (2010): 271 Mtoe
 - Per capita energy consumption: 1.42 toe/cap

■ Share of RE: (45%)

■ Fossil fuel consumption:

- Oil and by-products: mostly used in transport and for non-energy uses
- Natural gas: mostly used in industry (49%) and for power generation (34%)
- Coal: iron and steel industry mostly

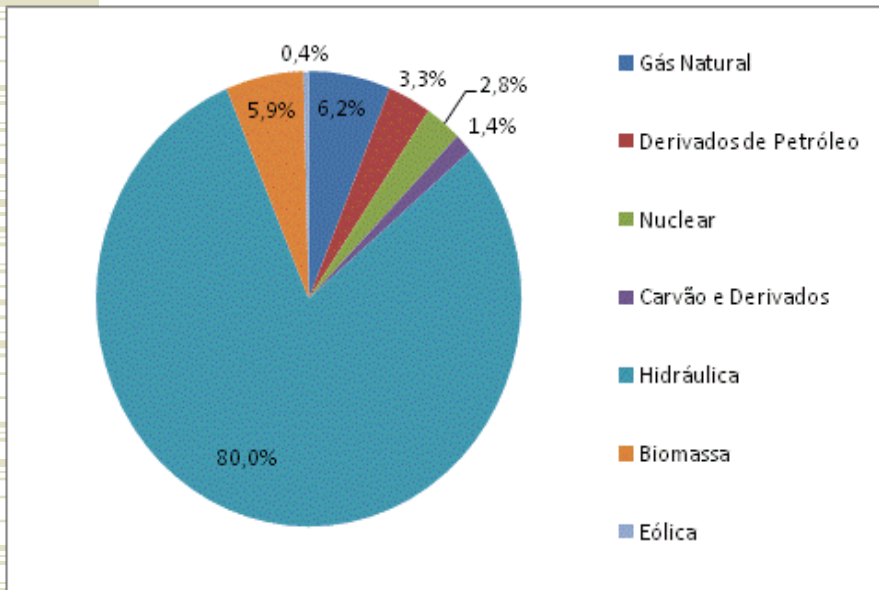


Share of different primary energy sources (2010)

Brazilian Energy Mix

◆ Power generation:

- Hydro responds for about 80% of all electricity produced in the country



Fonte: EPE (2011)

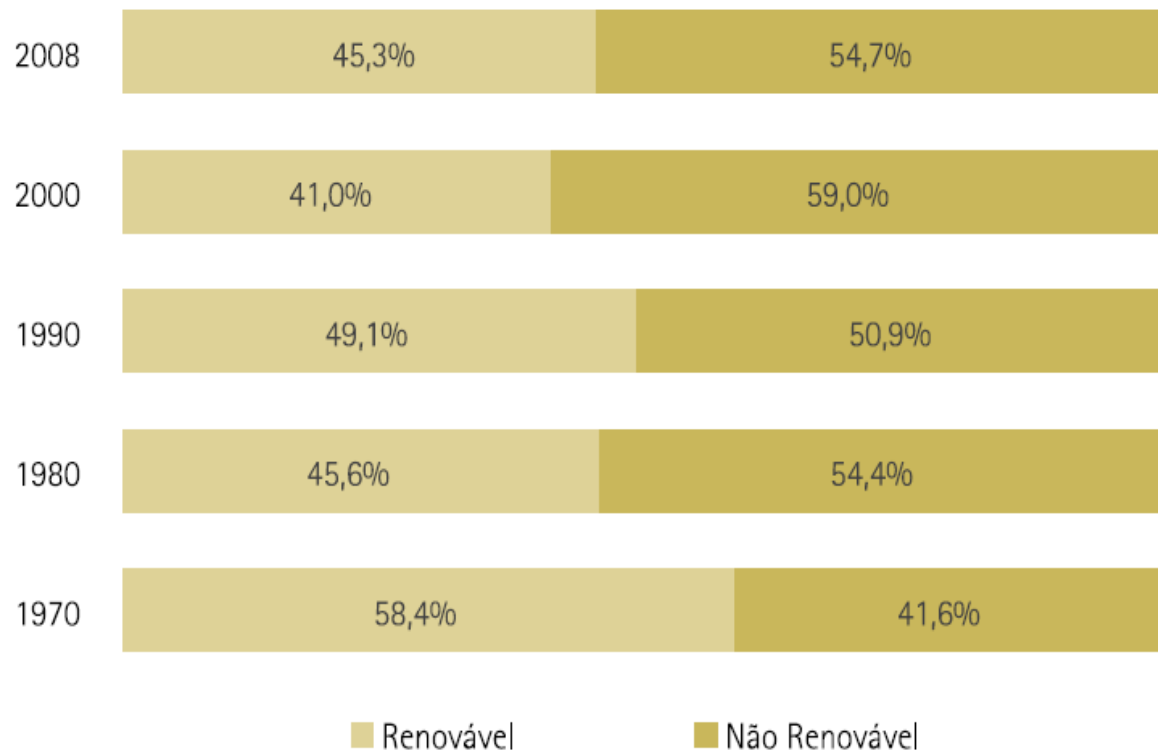
Share of different sources on power generation (2010)

■ Other REs:

- Biomass (particularly sugarcane bagasse): 6% of all electricity produced
- Wind
 - Small share today, but with a huge potential: 143 (50m) – 300 (100m) GW
- Solar
 - CSP: 1,6-2,4 TW
 - PV: 360 GW

How this Evolved over Time?

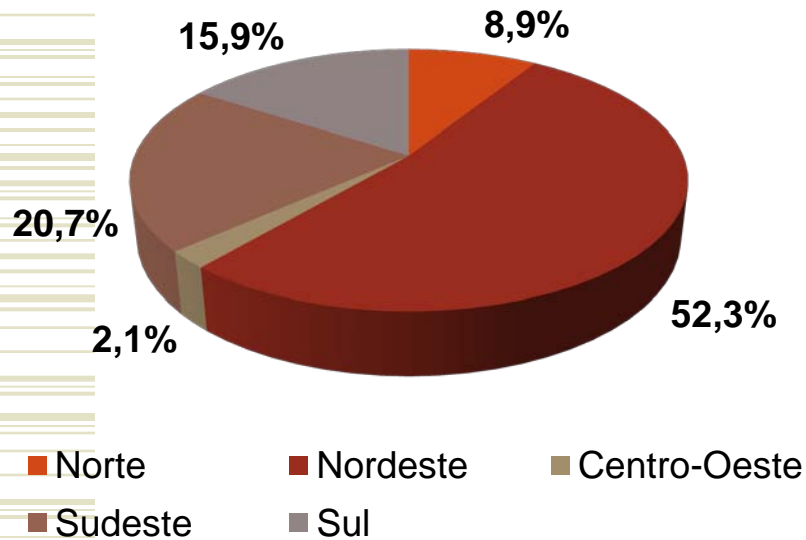
Participação de Fontes Renováveis na Oferta Interna de Energia



Wind Potential

143 GW ($V \geq 7\text{m/s}$; $h=50\text{m}$) (CEPEL, 2001).

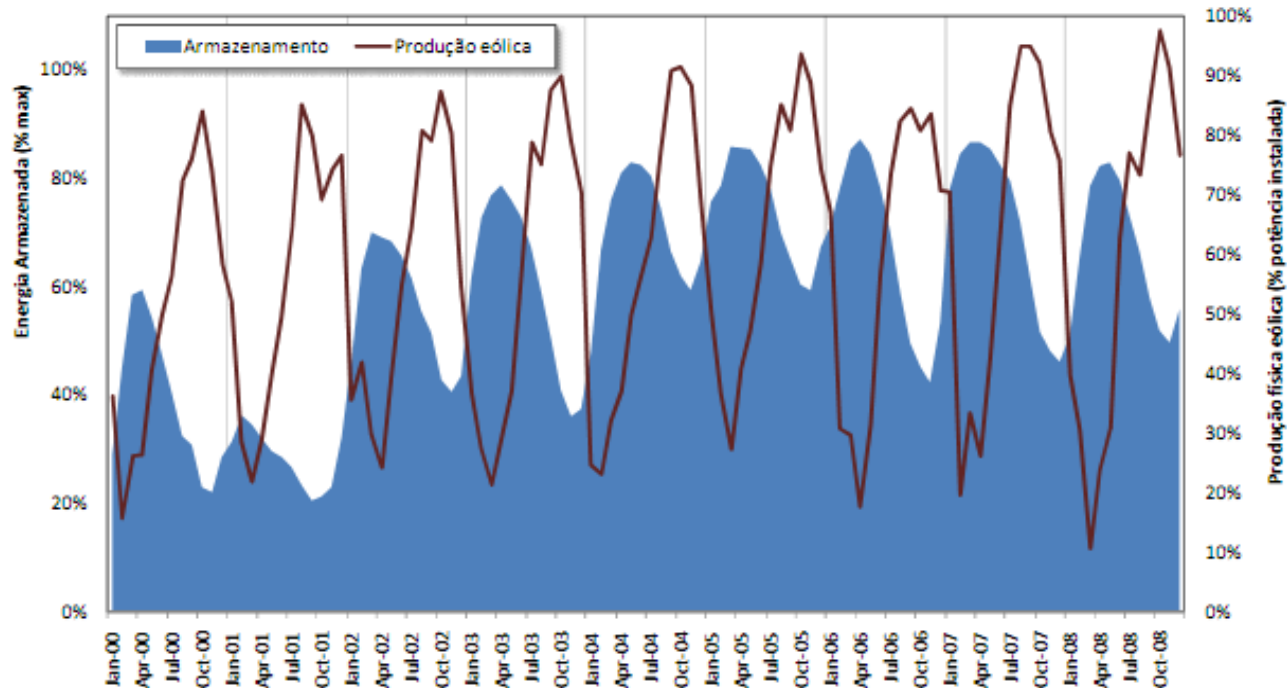
And higher than 300 GW at 100m (Simões, 2010).



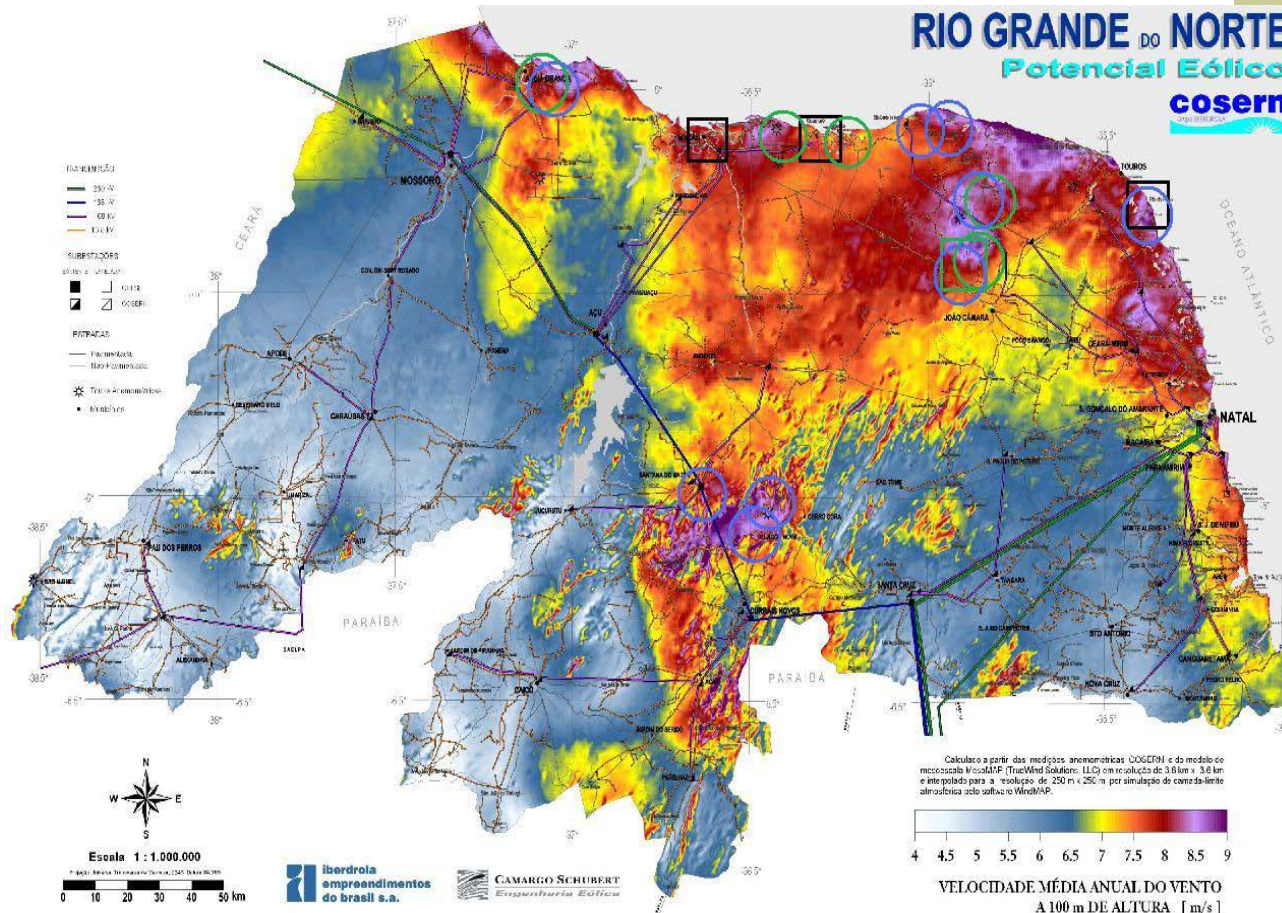
Wind Potencial

About the potencial:

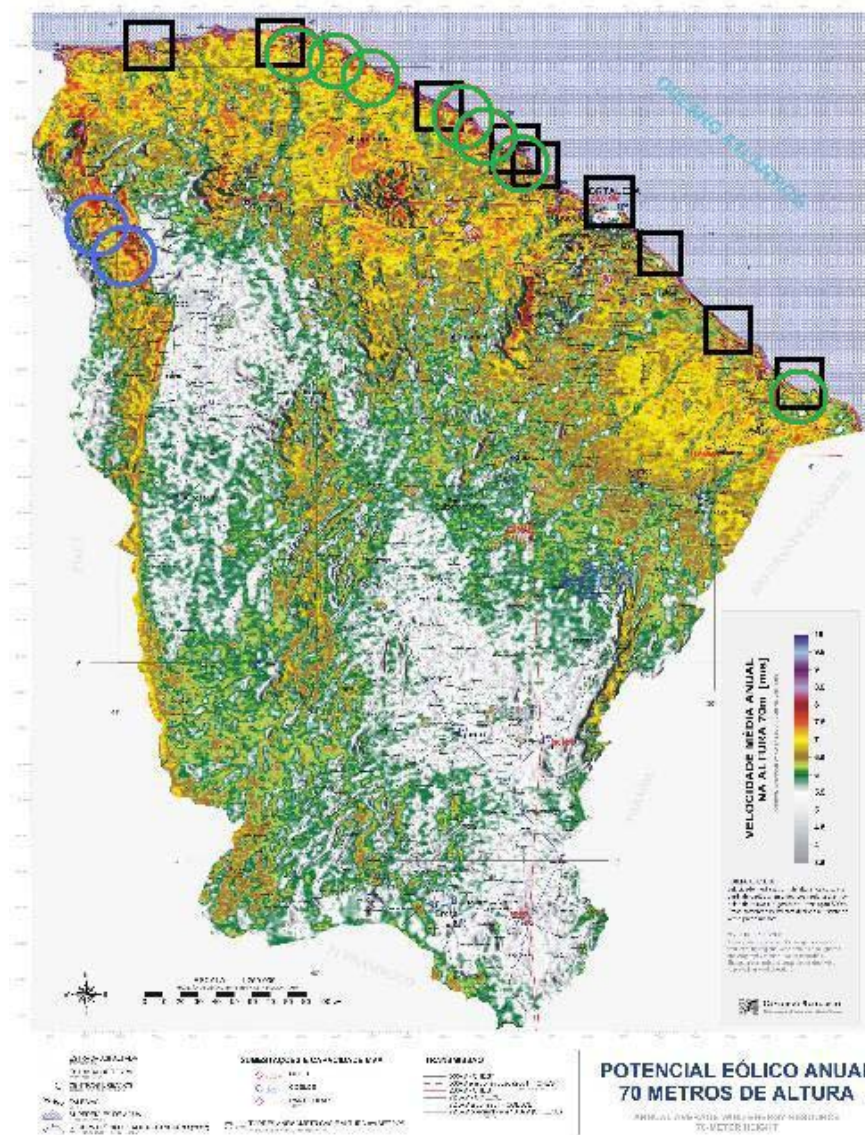
- It is not the bottleneck for the expansion in the country;
- Logical problems still persist: harbors and roads; and
- Need to expand transmission infrastructure.
- Good complementarity between hydro and wind



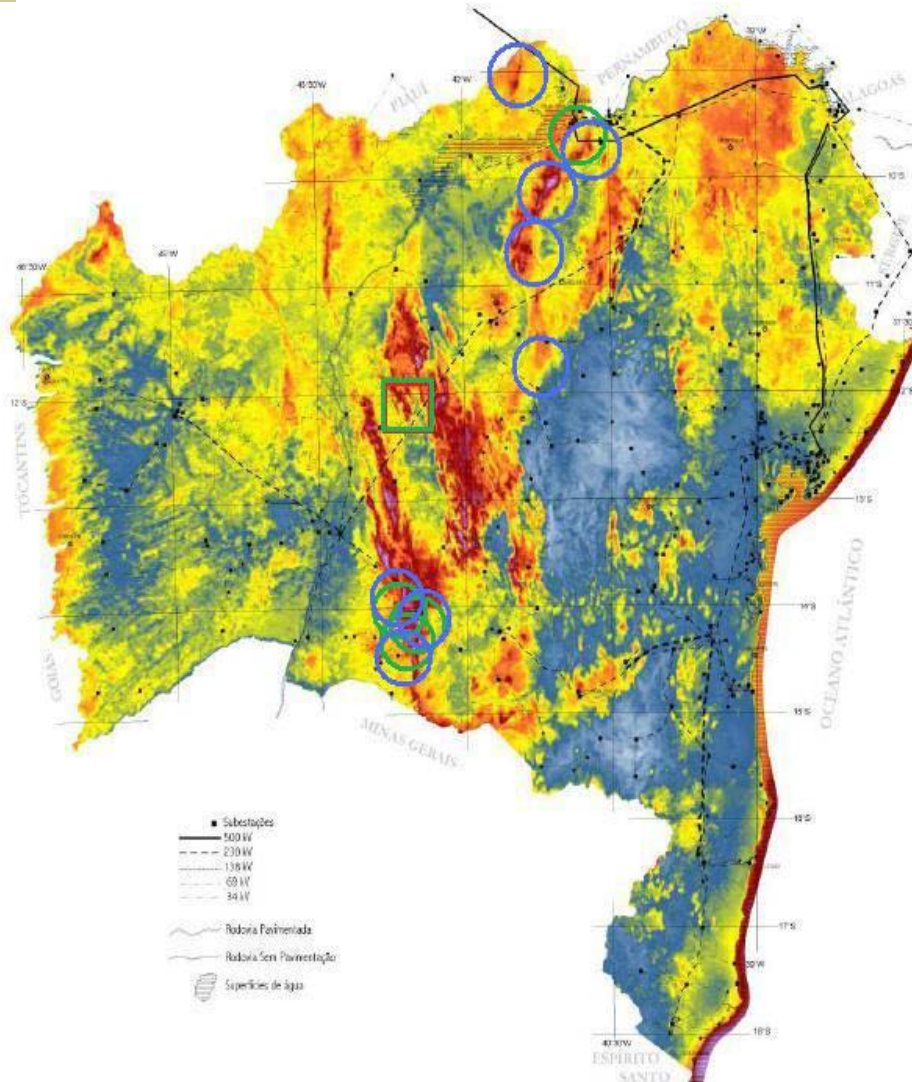
Wind Potencial



Wind Potencial



Wind Potencial



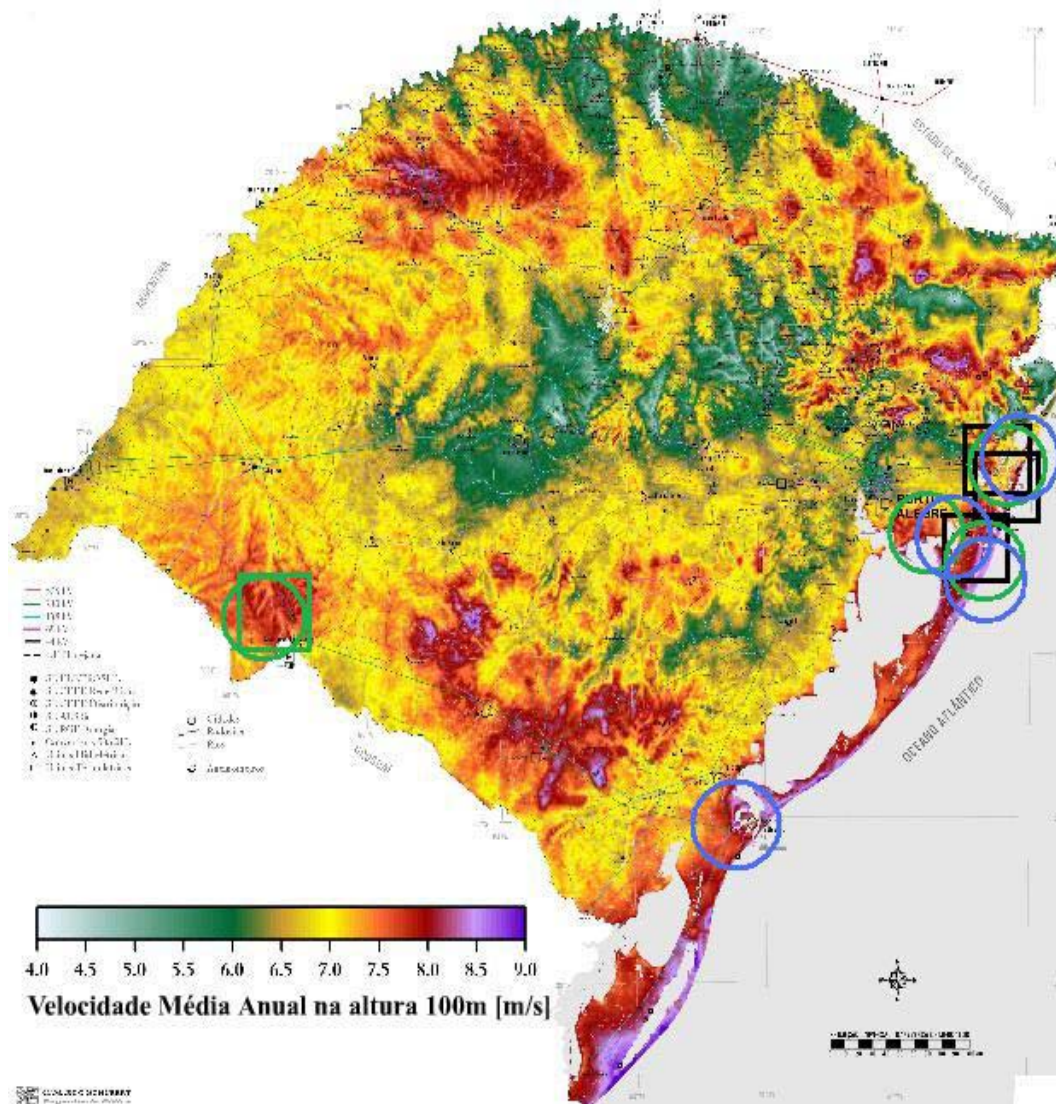
ESTADO DA BAHIA Atlas do Potencial Eólico



Potencial Eólico a 70m de Altura



Wind Potencial




Current State and Future Perspectives for Wind

Installed Capacity (MARCH/2011):

Tipo	Nº de Usinas	Potência (MW)	Participação
Hidrelétrica	501	77.210,3	68%
Eólica	50	926,9	1%
PCH	389	3.440,1	3%
Solar	4	0,1	0%
Termelétrica	1.399	29.856,9	26%
Termonuclear	2	2.007,0	2%
Total	2.345	113.441,3	100%

Capacidade contratada: 47,3 GW



Estado	Nº de Usinas	Distribuição	Potência (MW)	Distribuição
Ceará	17	34%	519	56%
Paraíba	12	24%	60	6%
Paraná	2	4%	3	0%
Pernambuco	7	14%	25	3%
Piauí	1	2%	18	2%
Rio de Janeiro	1	2%	28	3%
Rio G. do Norte	3	6%	102	11%
Rio G. do Sul	4	8%	158	17%
Santa Catarina	3	6%	14	2%
Total	50	100%	926,9	100%

Contracted Capacity: 3,3 GW (101 plants authorized or under construction)



Current State and Future Perspectives for Wind



Results from the Most Recent Bids

LFA 1	Nº de Projetos	Capacidade (MW)	Capacidade Média (MW)	Preço Médio (R\$/MWh)
PCH	6	96,74	46	134,99
Biomassa	12	541,9	140	138,85
Eólica	0	0	0	225
Total	18	638,64	186	137,56

2º LER - Eólica	
Nº de Projetos	71
Capacidade	1.805,7 MW
Capacidade Média	783,1 MW
Preço Médio	148,39

LFA 2 + LER 3	Nº de Projetos	Capacidade (MW)	Capacidade Média (MW)	Preço Médio (R\$/MWh)
PCH	7	131,5	69,8	141,93
Biomassa	12	712,9	190,6	144,2
Eólica	70	2047,8	899	130,86
Total	89	2.892,2	1.159,4	133,56

	2º LER/2009				2º LFA/2010				3º LER/2010			
	Projetos		Capacidade (MW)		Projetos		Capacidade (MW)		Projetos		Capacidade (MW)	
RN	23	32%	657	36%	30	60%	817,4	54%	9	45%	247,2	47%
BA	18	25%	390	22%	6	12%	326,4	21%	10	50%	261	49%
RS	8	11%	186	10%	9	18%	225,8	15%	1	5%	20	4%
CE	21	30%	542,7	30%	5	10%	150	10%	0	0%	0	0%
SE	1	1%	30	2%	0	0%	0	0%	0	0%	0	0%
Total	71	100%	1.805,7	100%	50	100%	1.519,6	100%	20	100%	528,2	100%

Current State and Future Perspectives for Wind

Projections vs. Contracts that have been celebrated:

PNE 2030 vs. PDE 2019

	Ano base	CI Ano Base (MW)*	Ano final	CI Ano Final (MW)	Média (MW a.a.)
PNE 2030 (EPE, 2007a)	2005	29	2030	4.653	185
PDE 2019 (EPE, 2010b)	2009	602	2019	6.041	544

* Valores obtidos no BIG (ANEEL, 2011a)

 ~3X

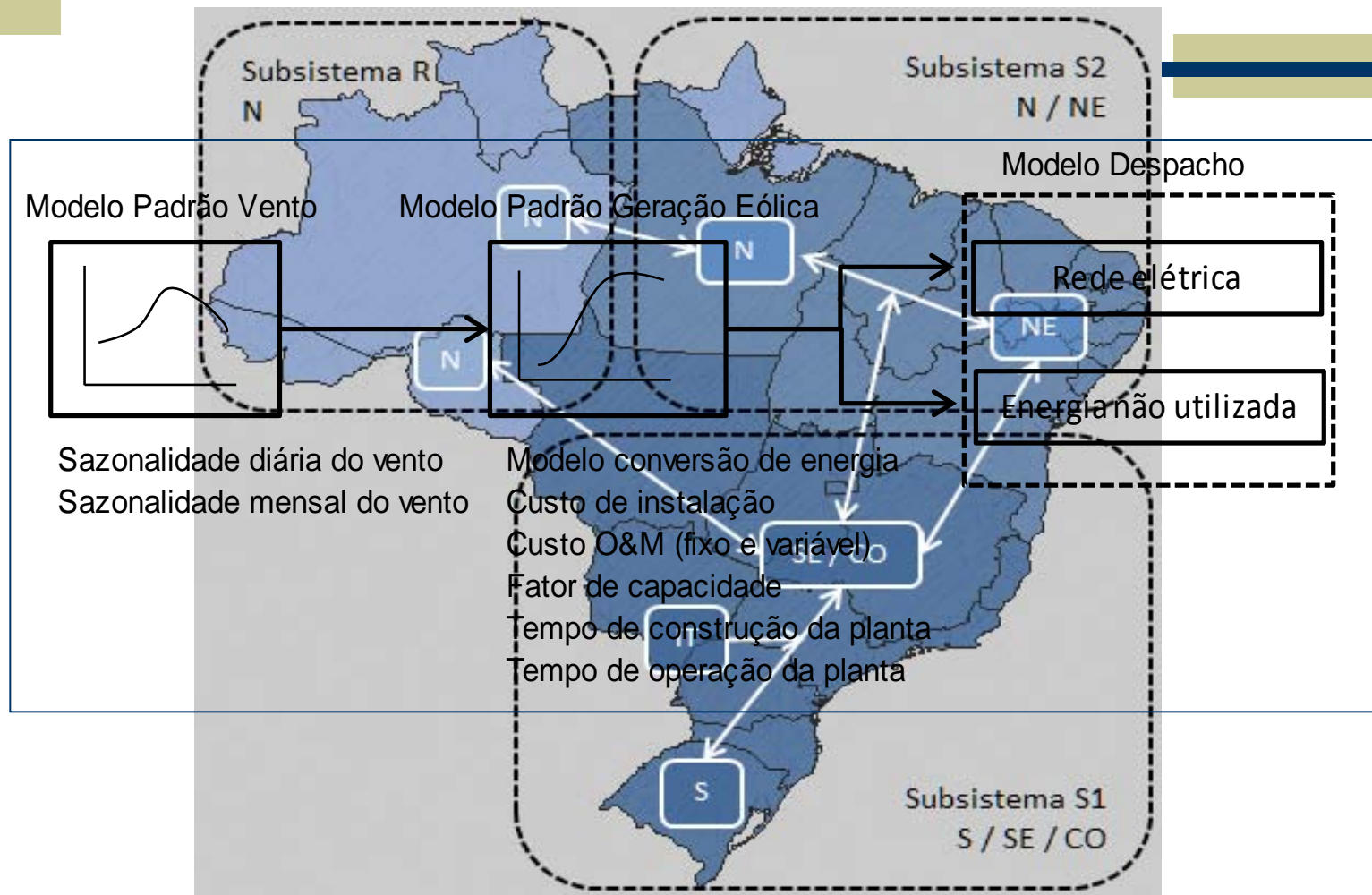
PDE 2019 vs. Leilões

	2012	2013	Incremento
Previsão PDE 2019 (EPE, 2010b)	3.241	3.641	400
Previsão Leilões	3.241	5.288,8	2.047,8

 ~5X

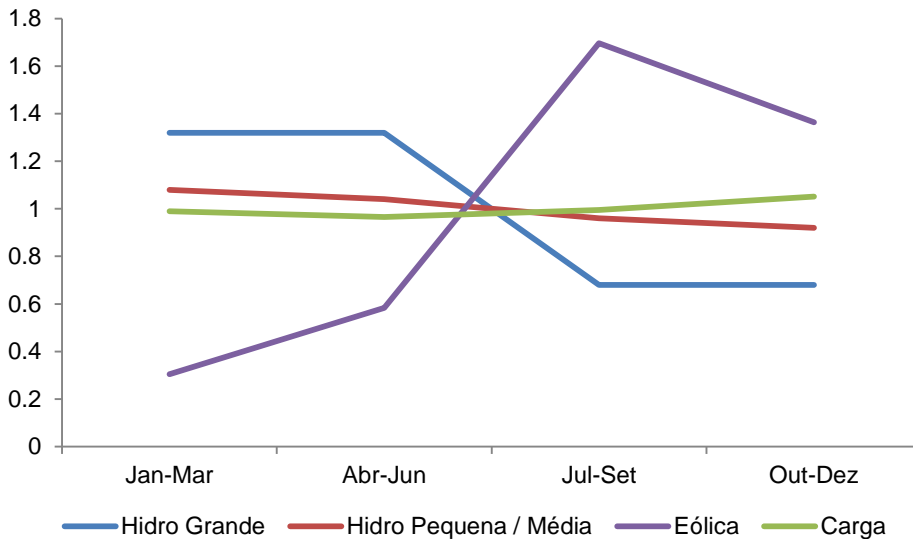
- Recent projections ended up being too pessimistic with respect to the real market

Interconnected Power System

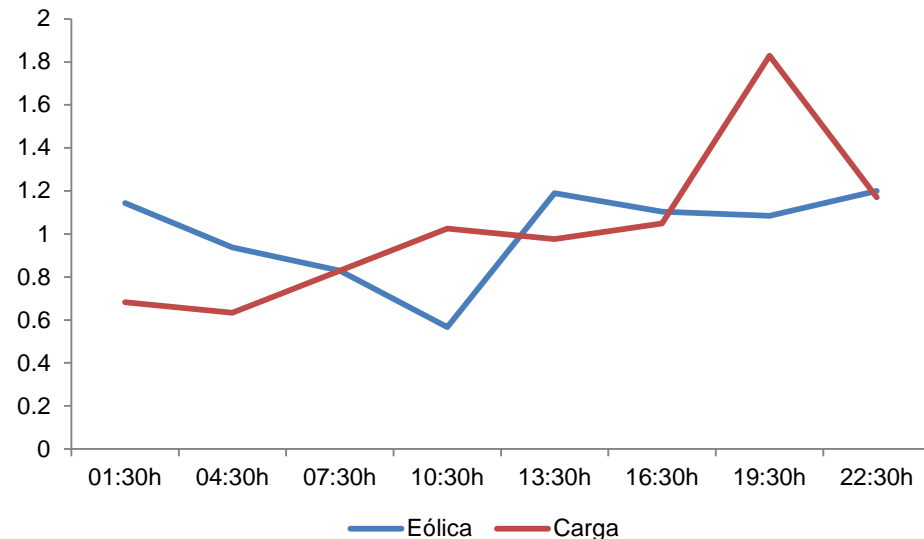


Hourly and Monthly Sazonality of Wind in the Northeast of Brazil

Monthly Sazonality in the Northeast



Hourly Sazonality in the Northeast



Excess Electricity from Power Generation from Wind in the Northeast

	GWh/period	2015	2020	2025	2030	2035	2040
Jan/Feb/Mar	1 - 6h	185	317	448	580	712	837
	6 - 10h	92	158	224	290	356	419
	10 - 18h	0	0	0	0	0	0
	18 - 21h	0	0	0	0	0	0
	21 - 24h	0	0	0	0	0	0
April/May/Jun	1 - 6h	295	506	716	927	1.137	1.337
	6 - 10h	0	253	358	463	569	668
	10 - 18h	0	0	0	0	0	0
	18 - 21h	0	0	0	0	0	0
	21 - 24h	0	0	0	0	0	0
Jul/Ago/Sept	1 - 6h	51	0	0	0	0	0
	6 - 10h	0	0	0	0	0	0
	10 - 18h	0	0	0	0	0	0
	18 - 21h	0	0	0	0	0	0
	21 - 24h	0	0	0	0	0	0
Oct/Nov/Dec	1 - 6h	67	0	0	0	0	0
	6 - 10h	0	0	0	0	0	0
	10 - 18h	0	0	0	0	0	0
	18 - 21h	0	0	0	0	0	0
	21 - 24h	0	0	0	0	0	0

Excess Electricity from Power Generation from Wind in the Northeast

Size of a PHEV50 Dedicated Car Fleet to Absorb the Excess

	Excess Electricity (GWh)	Load S2 (TWh)	%	Fleeta
2015	597	108	0,6%	447.907
2020	822	123	0,7%	616.604
2025	1.165	142	0,8%	873.522
2030	1.507	159	0,9%	1.130.440
2035	1.850	180	1,0%	1.387.360
2040	2.174	205	1,1%	1.630.324

→ PHEV5
0



Solar Potential in Brazil

Total Annual Solar Irradiation

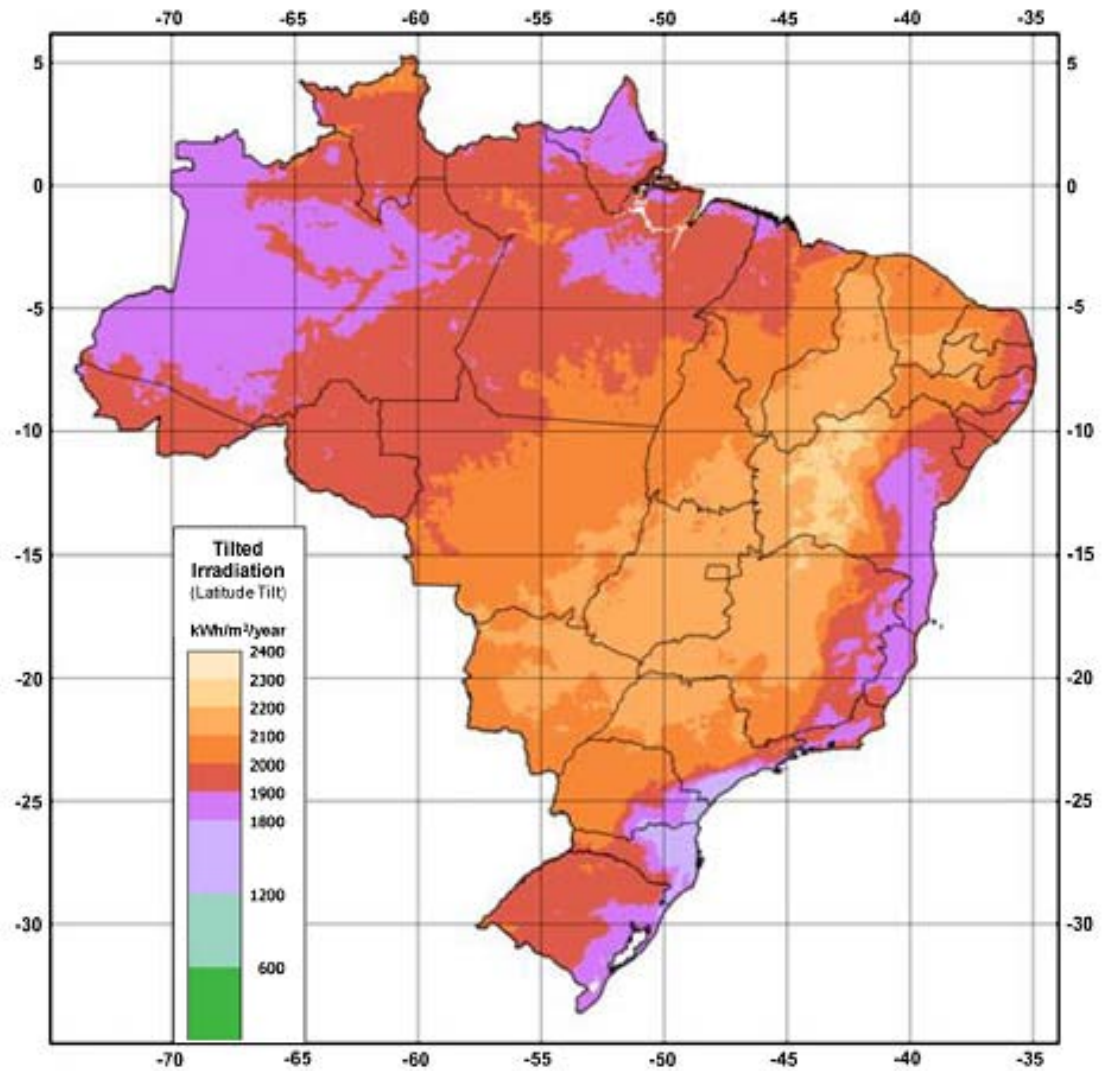
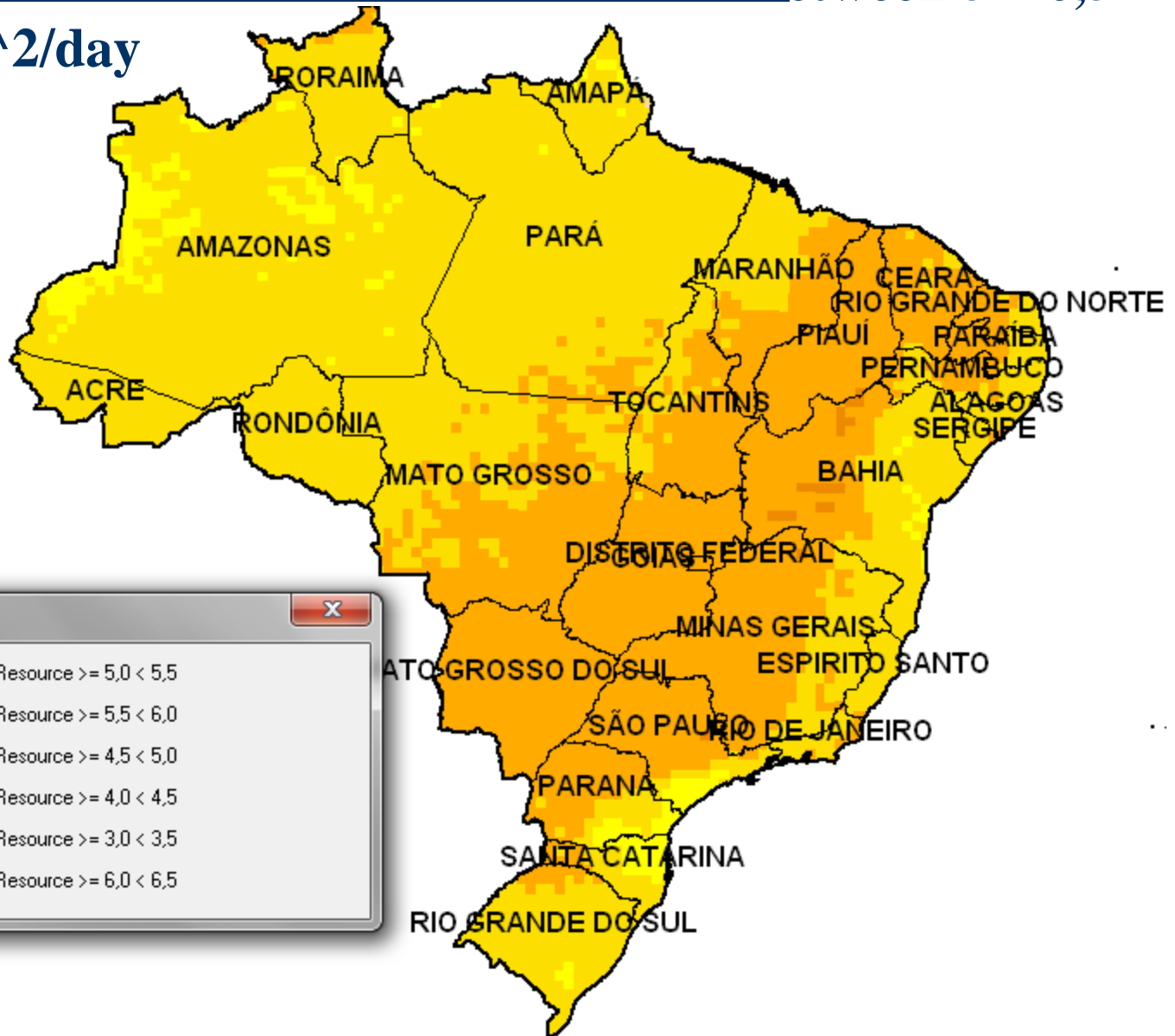


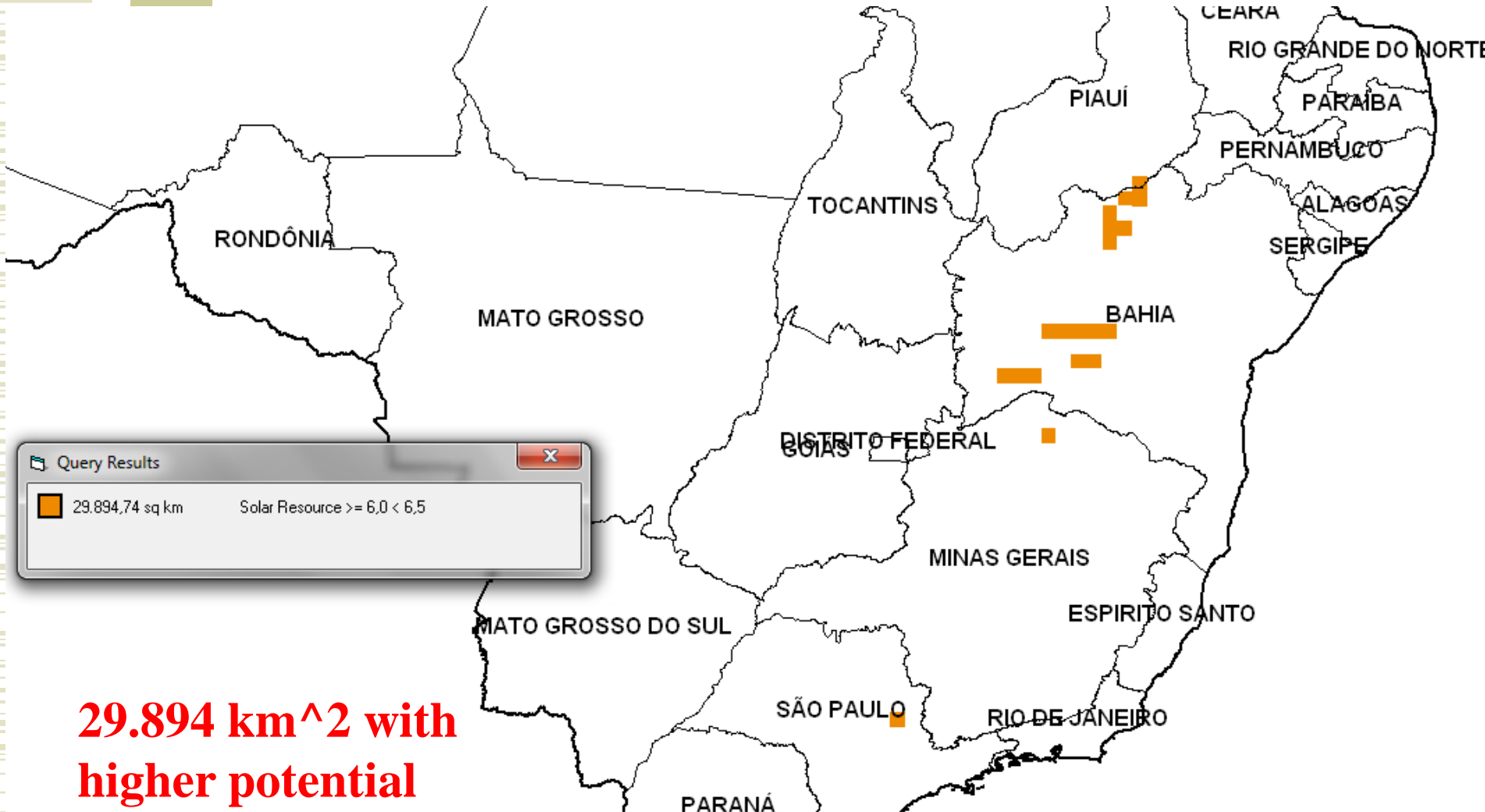
Fig. 4. Satellite-derived, total annual **latitude-tilted** irradiation map for Brazil, in kW h/m²/year.

Potential for PV Places with irradiation between 5 – 6,5 kWh/m²/day



	5.027.752,74 sq km	Solar Resource >= 5,0 < 5,5
	3.130.044,35 sq km	Solar Resource >= 5,5 < 6,0
	324.444,67 sq km	Solar Resource >= 4,5 < 5,0
	1.817,90 sq km	Solar Resource >= 4,0 < 4,5
	1.105,17 sq km	Solar Resource >= 3,0 < 3,5
	29.894,74 sq km	Solar Resource >= 6,0 < 6,5

Potential for PV Places with irradiation tilt between 6 – 6.5 kWh/m²/day

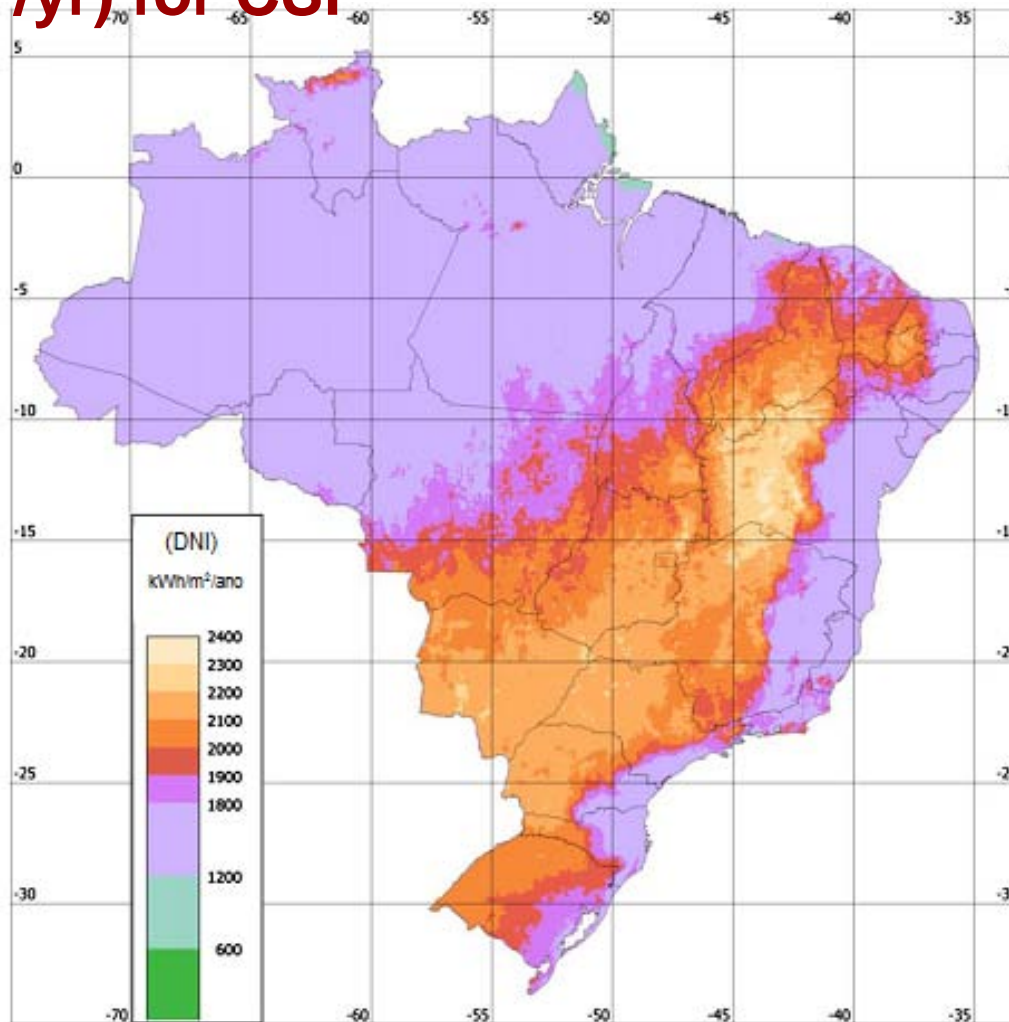


Query Results

29.894,74 sq km Solar Resource >= 6,0 < 6,5

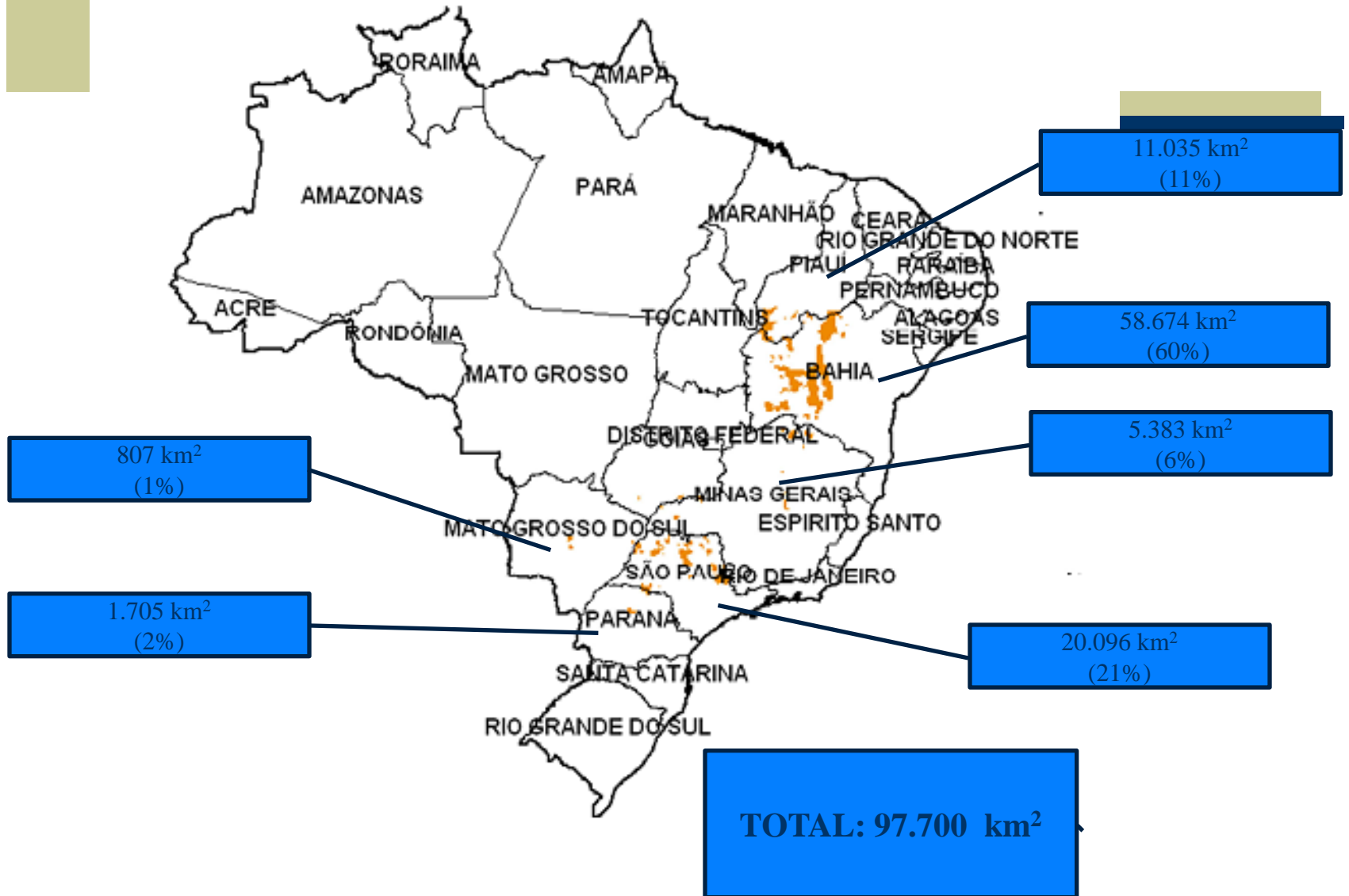
29.894 km² with higher potential for PV

Direct Normal Irradiation (DNI): total anual (kWh/m²/yr) for CSP



Fonte: VIANA *et al.*, 2011

Surface with technical potential for CSP



50% of the surface
with appropriate DNI

Total electric potencial from
CSP in Brasil (TWhe/yr):

3,664 TWhe/yr

Average annual power from CSP
(GWe)

Estado	Pot. inf. (GWe)	Pot. sup (GWe)
Bahia	978	1.467
Piauí	184	276
Total Nordeste (NE)	1.162	1.743
Mato Grosso do Sul	13	20
Total Sul (S)	13	20
Paraná	28	43
São Paulo	335	502
Minas Gerais	90	135
Total Cento- Oeste/ Sul-Este (CO/SE)	453	680
Total Brasil	1.628	2.443

Source: the authors