SESSION 4 (Plenary):

Economics and Demand for Non-Electric Applications

Meeting Room A

Paper: IAEA - CN-152 - 1

L. Martins Jr - Brazil

"*Economic Evaluation of Nuclear Desalination in the Northeastern region of Brazil*"

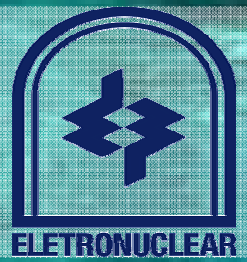

ELETRONUCLEAR

ECONOMIC EVALUATION OF NUCLEAR DESALINATION IN THE NORTHEASTERN REGION OF BRAZIL

Laercio Martins Jr.

April 2007

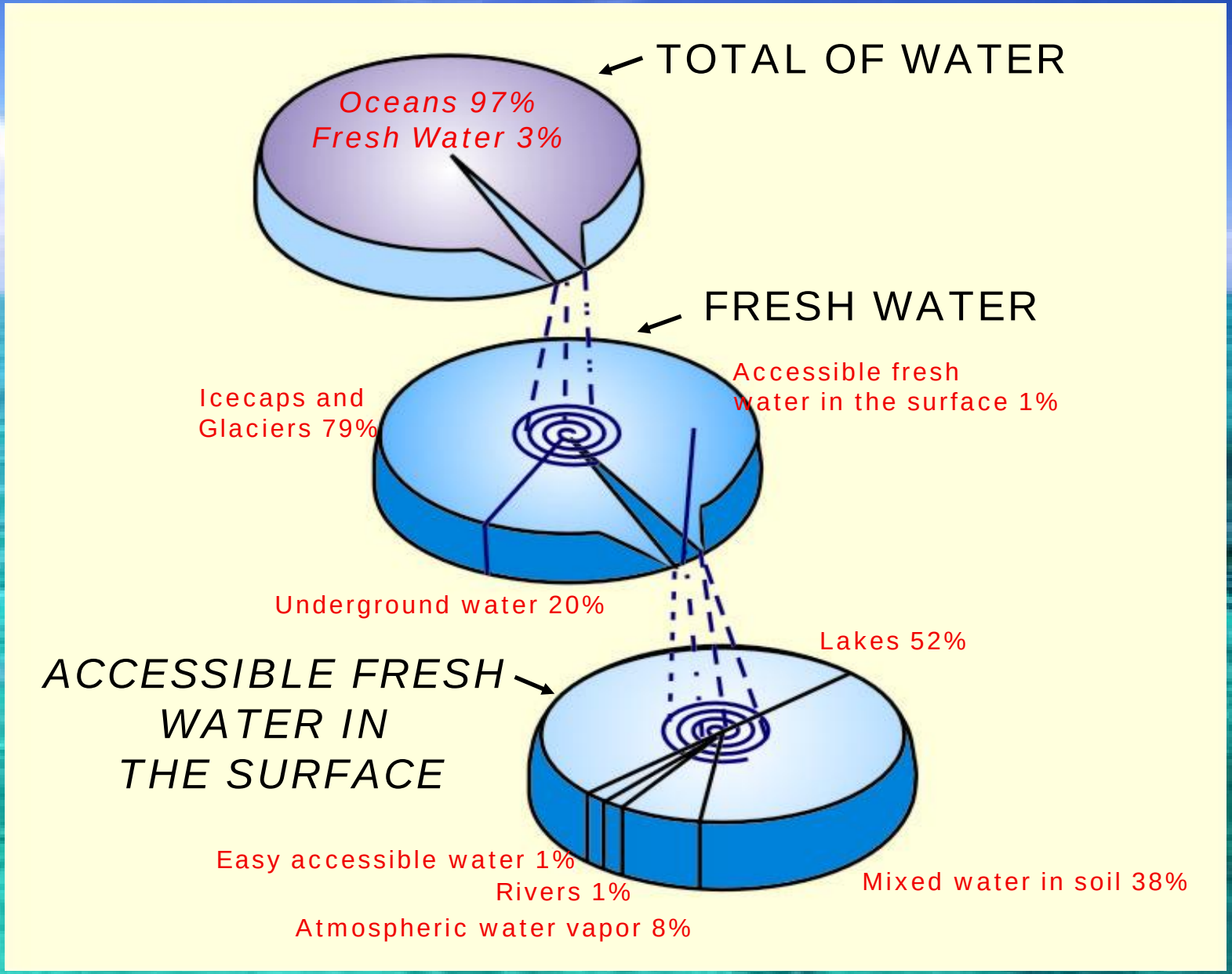
ELETRONUCLEAR - BRAZIL



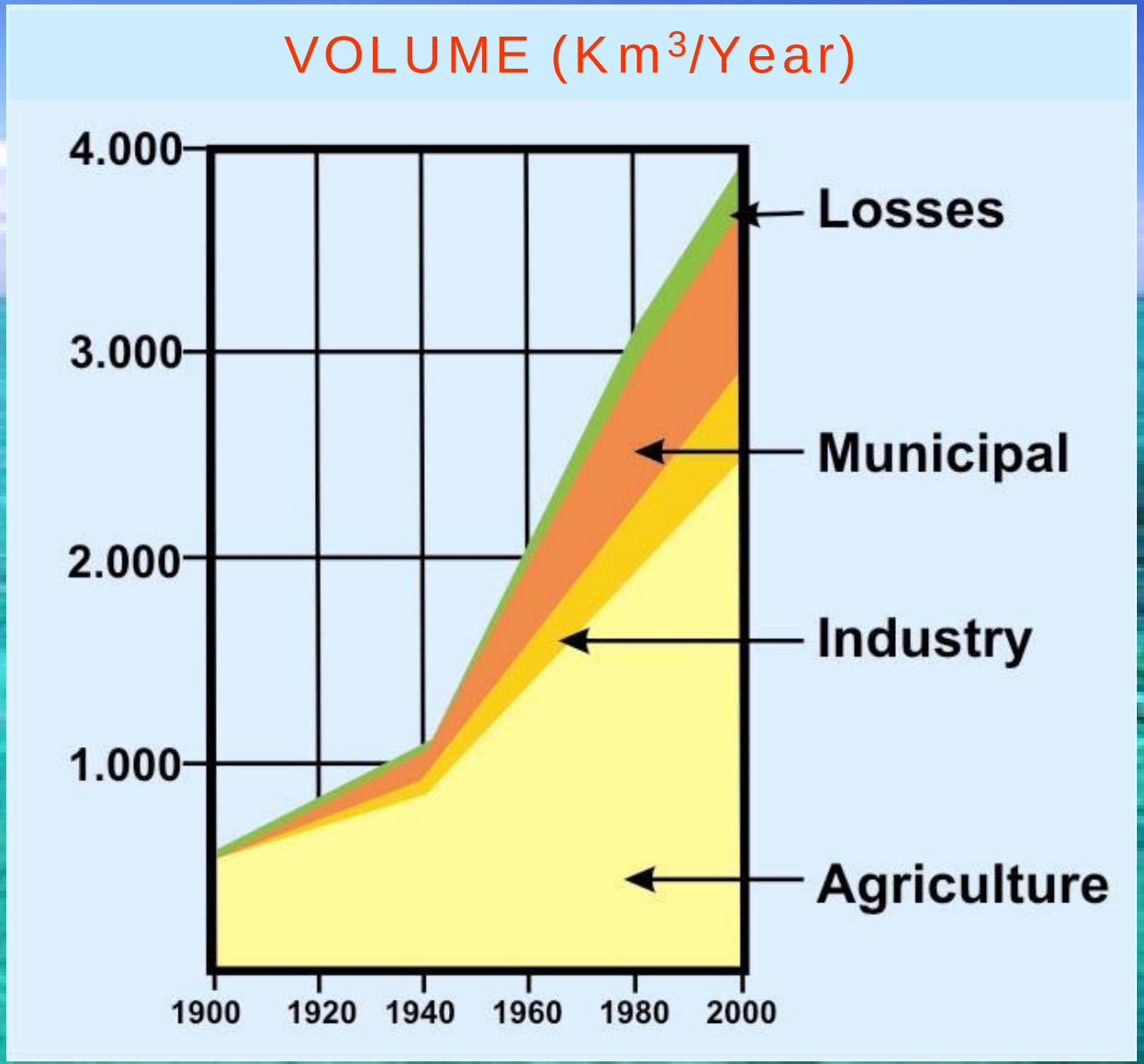
Earth: Planet Water

3/4 of the Planet are covered by water

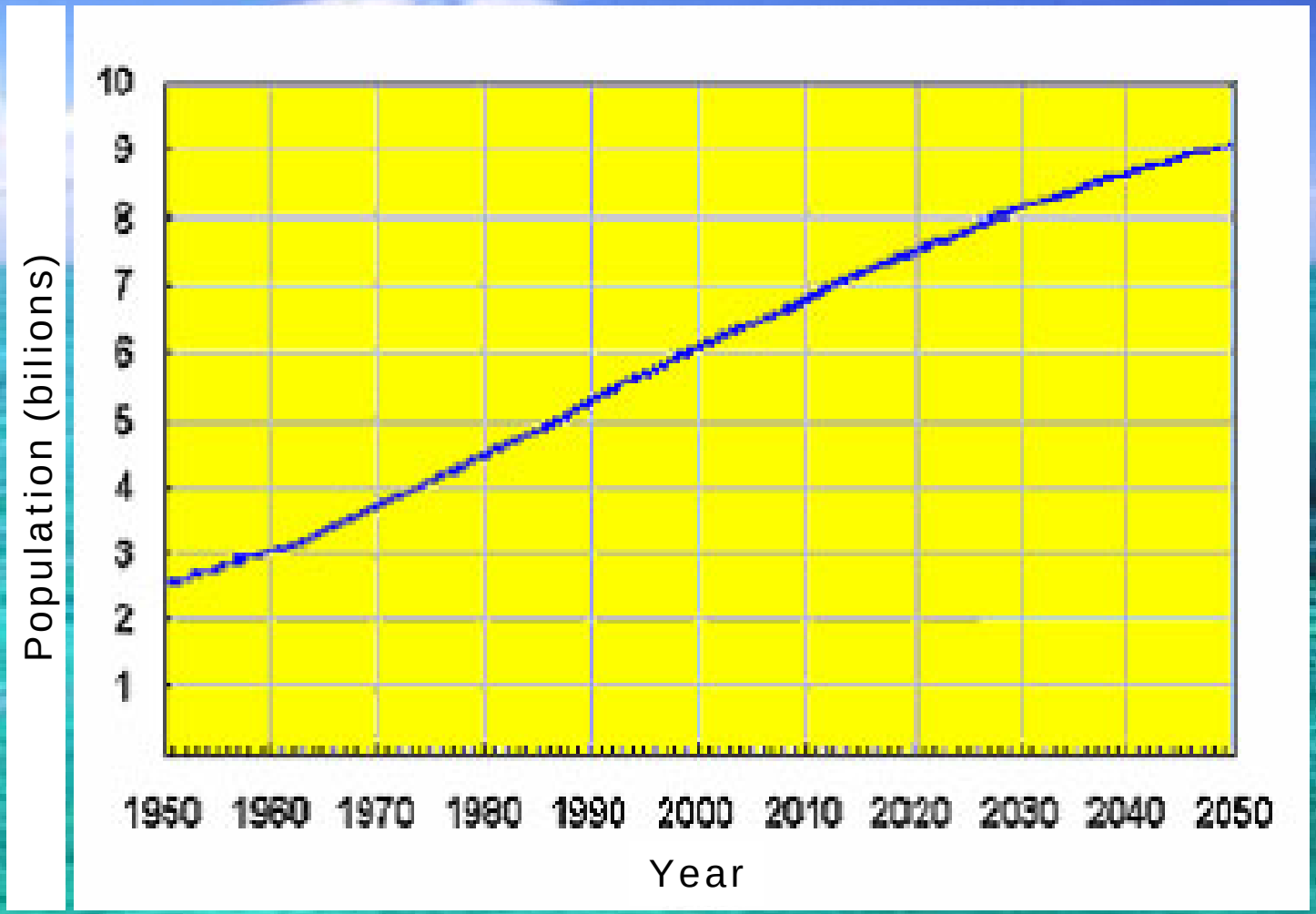
Water Distribuition in the world



Water use in the world



Word population 1950 - 2050



U.S. Censes Bureau, International Data Base10-2002

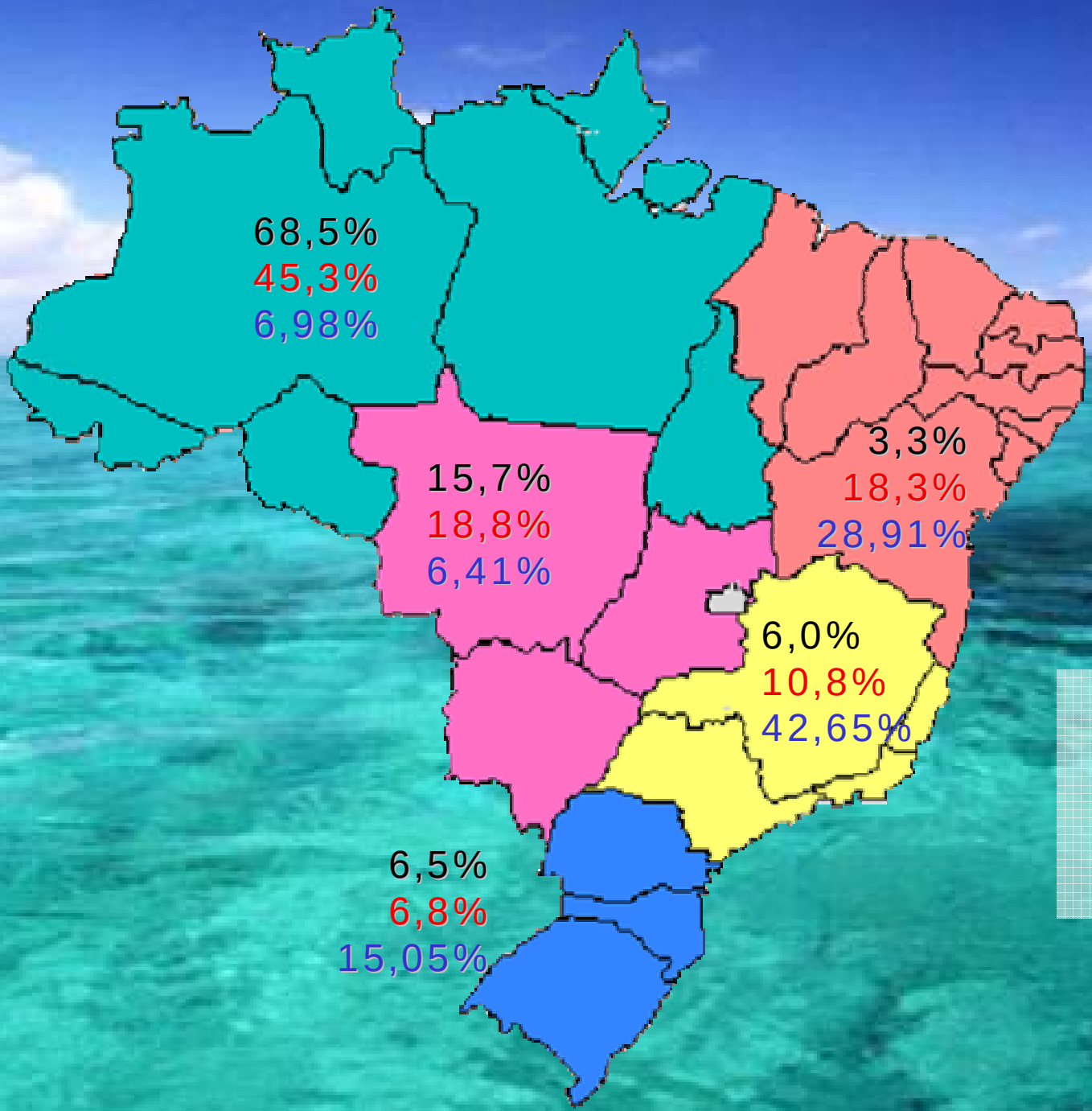
Geographical regions in Brazil

BRAZIL

NORTHEAST




Water resources in Brazil



Water resources

Surface Area

Population

Sea Water Desalination.
An Alternative for the Northeastern?

Most critical region in terms of water resources.

Many social and economic problems.

Highest number of persons without fresh water supply.

ANSWER ➔ YES

Options for Desalting Sea Water

MSF: Multi Stage Flash

RO: Reverse Osmosis

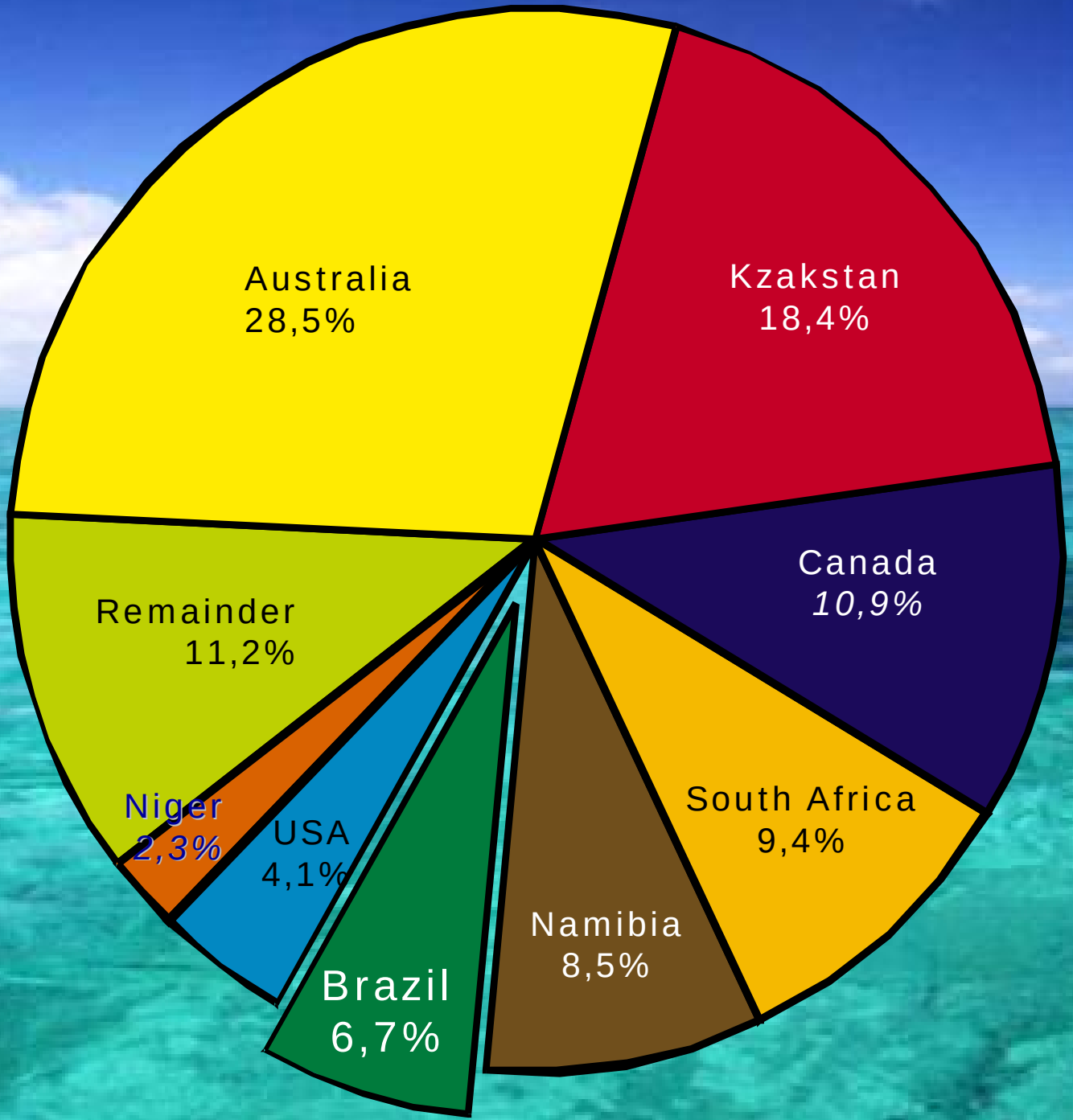
MED: Multiple Effect Destillation

Power Source: Natural Gas, Nuclear etc.

ASSUMPTIONS IN THIS STUDY:
PWR NUCLEAR POWER PLANT + MED

OBS: A COMPARISON WILL BE MADE WITH NATURAL GAS + MED

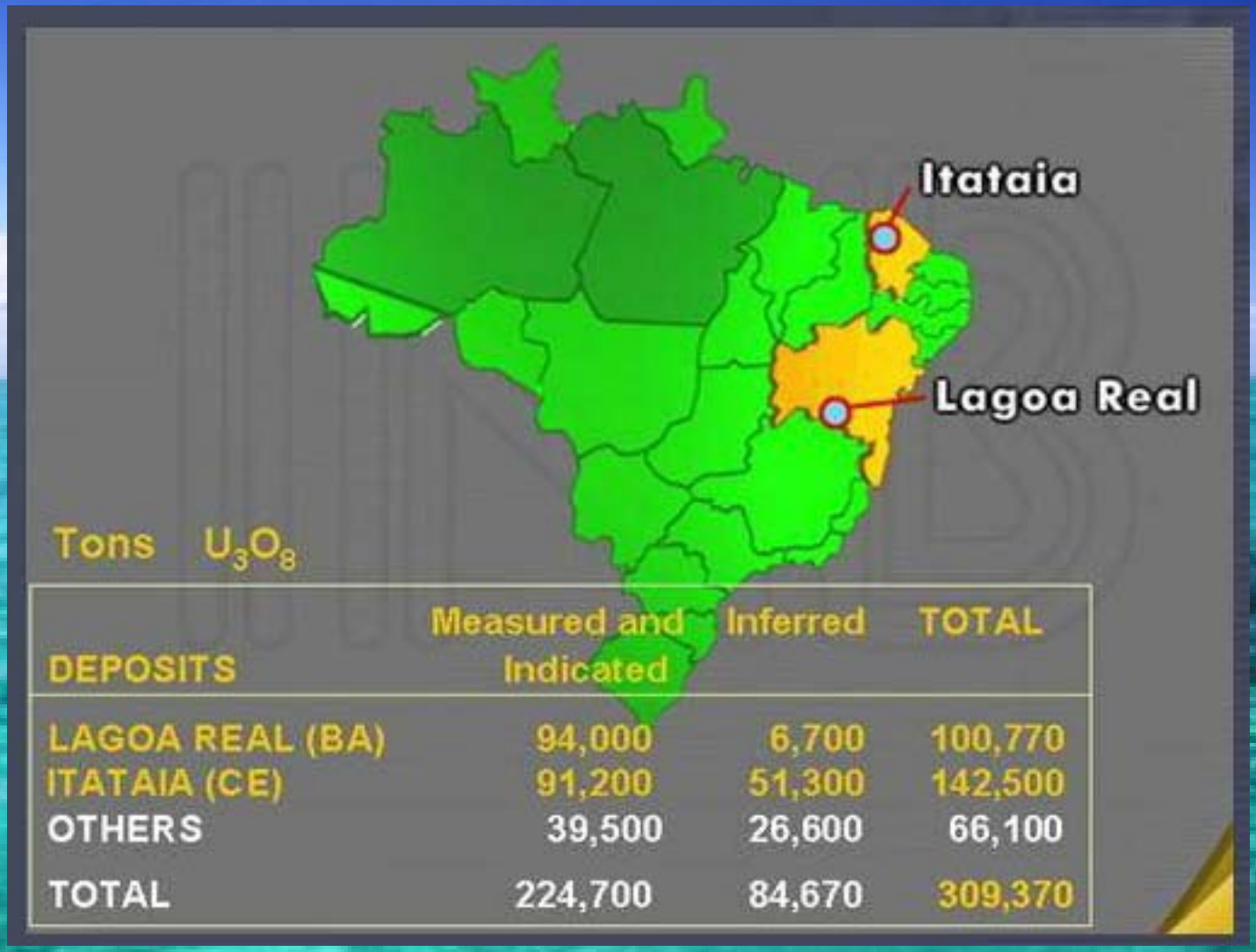
World Resources up to US$ 80/KgU



100% = 3.256.000 tU_3O_8

Brazil = 6th world resource

Proven Uranium Reserves



Tons U_3O_8

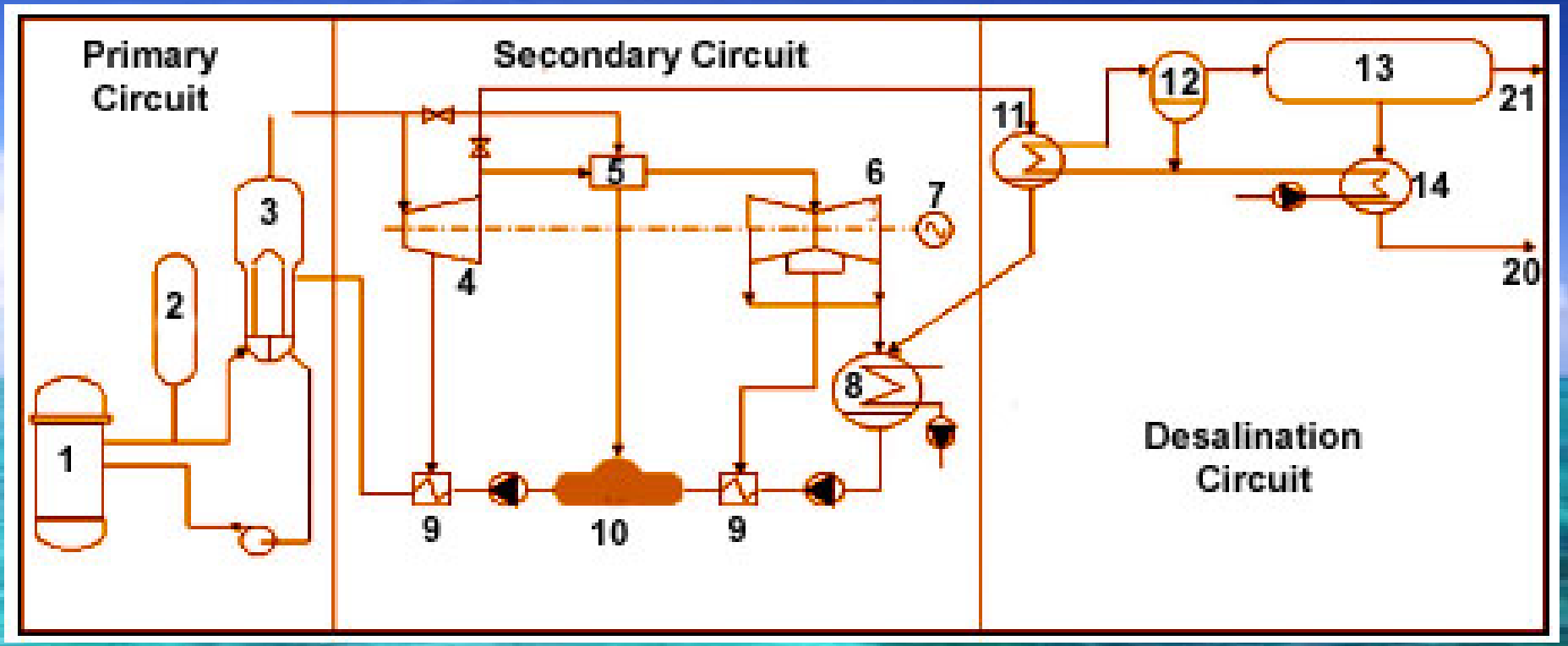
DEPOSITS	Measured and Indicated	Inferred	TOTAL
LAGOA REAL (BA)	94,000	6,700	100,770
ITATAIA (CE)	91,200	51,300	142,500
OTHERS	39,500	26,600	66,100
TOTAL	224,700	84,670	309,370

Prospected area Only 30% of national territory
up to 100 Meters deep

Expected Uranium Reserves

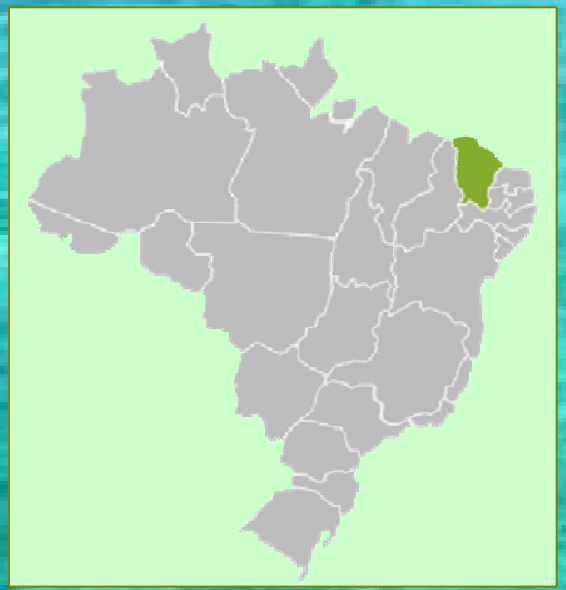
After prospected all the national territory
Brazil should be the
3rd MAJOR WORLD RESERVE

PWR – MED Coupling Schme



1. Reactor
2. Pressurizer
3. Steam Generator
4. High Pressure Turbine
5. Main Steam Heater
6. Low Pressure Turbine
7. Electric Generator
8. Main Condenser
9. Steam Generator Main Feedwater Heaters
10. De-aerator
11. Sea Water Main Heater
12. Flash Tank
13. MED Plant
14. MED Output Condenser
20. Desalted Water Out
21. Brine Out

Site considered for the studies



Total Capital Costs, Electricity and Desalted Water Production

	US$ x 10**3			US$ x 10**3		
	Nuclear Generation (MWe)			Gas Generation (MWe)		
	300	600	1000	300	600	1000
Capital Cost for Power Plant	600.000	1.200.000	2.000.000	150.000	300.000	500.000
Capital Cost for Desalting Unit	70.000	70.000	70.000	70.000	70.000	70.000
Total	670.000	1.270.000	2.070.000	220.000	370.000	570.000

	Nuclear Generation (MWe)			Gas Generation (MWe)		
Electricity & Water Production	300	600	1000	300	600	1000
Maximum Electrical Power (MWe)	200	500	900	200	500	900
Maximum Water Production (m^3/day)	115.000	115.000	115.000	115.000	115.000	115.000

O & M Costs, Tariffs and Taxes

Power Generation Costs		Nuclear	Gas 25 years	Gas +15 years
O & M	US$/MWh	8,00	6,25	5,00
Decommissioning	Years	40	-	-
Depreciation	Years	25	25	0
Fuel	US$/MWh	6,00	17,06	17,06
Desalting Costs				
O & M	US$/m³	0,138	0,138	0,138
Depreciation	Years	25	25	0
Chemical Products	US$/m³	0,025	0,025	0,025

Federal Taxes and Tariffs		Nuclear	Gas
Electric Energy Tariff	US$/MWh	58,00	44,81
CONFIS	%	7,00	7,00
PASEP	%	1,30	1,30
ICMS	%	17,00	17,00
Income Tax Rate	%	25,00	25,00
Social Contribution	%	9,00	9,00

Long Term Payments for a 300 MWe Plants

US$ x 10**3

300 Mwe Nuclear Power Plant

Year	Description	Interest	Payment	Amortiz.	Balance
1	Construction	8.710		0	142.710
2	Construction	17.986		0	294.696
3	Construction	27.865		0	456.561
4	Construction	38.386		0	628.948
5	Construction	49.592		0	812.540
6	Grace period	52.815	52.815	0	812.540
7	Grace period	52.815	52.815	0	812.540
8	Grace period	52.815	52.815	0	812.540
9	Grace period	52.815	52.815	0	812.540
10	Amortization	52.815	167.845	115.030	697.510
11	Amortization	45.338	167.845	122.507	575.003
12	Amortization	37.375	167.845	130.470	444.533
13	Amortization	28.895	167.845	138.950	305.583
14	Amortization	19.863	167.845	147.982	157.601
15	Amortization	10.244	167.845	157.601	0
		548.330			

Interest Rate: TJLP= 6.5% per year 6,5

US$ x 10**3

300 Mwe Natural Gas Power Plant

Year	Description	Interest	Payment	Amortiz.	Balance
1	Construction	4.767		0	78.100
2	Construction	9.843		0	161.277
3	Construction	15.250		0	249.859
4	Grace period	16.241	16.241	0	249.859
5	Grace period	16.241	16.241	0	249.859
6	Grace period	16.241	16.241	0	249.859
7	Grace period	16.241	16.241	0	249.859
8	Amortization	16.241	51.613	35.372	214.487
9	Amortization	13.942	51.613	37.671	176.816
10	Amortization	11.493	51.613	40.120	136.696
11	Amortization	8.885	51.613	42.728	93.968
12	Amortization	6.108	51.613	45.505	48.463
13	Amortization	3.150	51.613	48.463	0
		154.642			

Interest Rate: TJLP= 6.5% per year 6,5

Long Term Payments for a 600 MWe Plants

US$ x 10**3

600 Mwe Nuclear Power Plant

Year	Description	Interest	Payment	Amortiz.	Balance
1	Construction	16.510		0	270.510
2	Construction	34.093		0	558.603
3	Construction	52.819		0	865.422
4	Construction	72.762		0	1.192.185
5	Construction	94.002		0	1.540.187
6	Grace period	100.112	100.112	0	1.540.187
7	Grace period	100.112	100.112	0	1.540.187
8	Grace period	100.112	100.112	0	1.540.187
9	Grace period	100.112	100.112	0	1.540.187
10	Amortization	100.112	318.154	218.042	1.322.145
11	Amortization	85.939	318.154	232.214	1.089.931
12	Amortization	70.846	318.154	247.308	842.623
13	Amortization	54.770	318.154	263.383	579.239
14	Amortization	37.651	318.154	280.503	298.736
15	Amortization	19.418	318.154	298.736	0
		1.039.371			

Interest Rate: TJLP= 6.5% per year 6,5

US$ x 10**3

600 Mwe Natural Gas Power Plant

Year	Description	Interest	Payment	Amortiz.	Balance
1	Construction	8.017		0	131.350
2	Construction	16.554		0	271.238
3	Construction	25.647		0	420.218
4	Grace period	27.314	27.314	0	420.218
5	Grace period	27.314	27.314	0	420.218
6	Grace period	27.314	27.314	0	420.218
7	Grace period	27.314	27.314	0	420.218
8	Amortization	27.314	86.804	59.490	360.729
9	Amortization	23.447	86.804	63.356	297.372
10	Amortization	19.329	86.804	67.475	229.898
11	Amortization	14.943	86.804	71.860	158.037
12	Amortization	10.272	86.804	76.531	81.506
13	Amortization	5.298	86.804	81.506	0
		260.079			

Interest Rate: TJLP= 6.5% per year 6,5

Long Term Payments for a 1000 MWe Plants

US$ x 10**3

1000 Mwe Nuclear Power Plant

Year	Description	Interest	Payment	Amortiz.	Balance
1	Construction	26.910		0	440.910
2	Construction	55.569		0	910.479
3	Construction	86.091		0	1.410.570
4	Construction	118.597		0	1.943.167
5	Construction	153.216		0	2.510.383
6	Grace period	163.175	163.175	0	2.510.383
7	Grace period	163.175	163.175	0	2.510.383
8	Grace period	163.175	163.175	0	2.510.383
9	Grace period	163.175	163.175	0	2.510.383
10	Amortization	163.175	518.566	355.391	2.154.993
11	Amortization	140.075	518.566	378.491	1.776.501
12	Amortization	115.473	518.566	403.093	1.373.408
13	Amortization	89.272	518.566	429.294	944.114
14	Amortization	61.367	518.566	457.198	486.916
15	Amortization	31.650	518.566	486.916	0
		1.694.093			

Interest Rate: TJLP= 6.5% per year 6,5

US$ x 10**3

1000 Mwe Natural Gas Power Plant

Year	Description	Interest	Payment	Amortiz.	Balance
1	Construction	12.350		0	202.350
2	Construction	25.503		0	417.853
3	Construction	39.510		0	647.363
4	Grace period	42.079	42.079	0	647.363
5	Grace period	42.079	42.079	0	647.363
6	Grace period	42.079	42.079	0	647.363
7	Grace period	42.079	42.079	0	647.363
8	Amortization	42.079	133.725	91.646	555.717
9	Amortization	36.122	133.725	97.603	458.114
10	Amortization	29.777	133.725	103.947	354.167
11	Amortization	23.021	133.725	110.704	243.463
12	Amortization	15.825	133.725	117.900	125.563
13	Amortization	8.162	133.725	125.563	0
		400.663			

Interest Rate: TJLP= 6.5% per year 6,5

Case 1

Power Levels (Mwe)	Nuclear 300	Nuclear 600	Nuclear 1000	Gas 300	Gas 600	Gas 1000
Minimum Desalted Water Price (US$/m³)	1,60	1,72	1,89	1,09	0,77	0,35

Power Levels (Mwe)	Nuclear 300	Nuclear 600	Nuclear 1000	Gas 300	Gas 600	Gas 1000
Net Present Value	0	0	0	0	0	0

SELIC return rate: 13% per year

Costs of fresh water in the State of Ceará.

RESIDENTIAL		
Normal	Consumption (m^3)	Tariff (US$/$m^3$)
	0 - 10	0,49
	11 - 15	0,78
	16 - 20	0,83
	21 - 50	1,40
	> 50	2,48
Social	0 - 10	0,29

COMMERCIAL 1	
Consumption (m^3)	Tariff (US$/$m^3$)
0 - 13	0,82
COMMERCIAL 2	
Consumption (m^3)	Tariff (US$/$m^3$)
0 - 50	1,65
> 50	2,48

INDUSTRIAL	
Consumption (m^3)	Tariff (US$/$m^3$)
0 - 15	1,44
16 - 50	1,65
> 50	2,48
PUBLIC SERVICES	
0 - 15	0,95
16 - 50	1,38
> 50	2,06

Case 2

Power Levels (MWe)	Nuclear 300	Nuclear 600	Nuclear 1000	Gas 300	Gas 600	Gas 1000
No Desalted Water	0	0	0	0	0	0

Power Levels (MWe)	Nuclear 300	Nuclear 600	Nuclear 1000	Gas 300	Gas 600	Gas 1000
Net Present Value US$ x 10**3	-136.904	-49.718	-60.561	33.563	115.715	191.932

SELIC return rate: 13% per year

Case 3

Initial Eletricity Tariff US$ 58/MWh

Initial Gas Tariff US$ 44,81/MWh

	Nuclear			Gas		
Power Levels (Mwe)	300	600	1000	300	600	1000
Lowest Electric Tariff US$/Mwe	36,84	50,74	54,86	11,46	28,44	33,47
Max. Desalted Water Price US$/m³	2,48	2,48	2,48	2,48	2,48	2,48

	Nuclear			Gas		
Power Levels (Mwe)	300	600	1000	300	600	1000
Net Present Value	0	0	0	0	0	0

SELIC return rate: 13% per year

Main Conclusions

- The desalting process is an alternative for the water shortage in the region and provides extra economic resources for investments in distribution expansion;
- Its positive social benefits are unquestionable;
- Nuclear option is not more competitive than the natural gas option Reasons:
  - *costs for Nuclear are much higher than for Natural Gas*
  - *Nuclear plants considered are double purpose plants*
- Desalted water production can aggregate value to any of the plants considered;
- Possibility of reduction in electric tariffs for specially selected desalted water tariffs;
- "Small plants" have more flexibility for adjustment to adverse economic and competitive environments than large ones;
- Nuclear Plants do not contribute for the Green House Effect and will be economic viable if coupled to desalting units.


THANK YOU FOR
YOUR ATTENTION
OARAI, JAPAN, APRIL 17 th, 2007