TRAINING AND DIALOGUE PROGRAMS

Energy Policy(A)
集団研修「エネルギー政策（A）」
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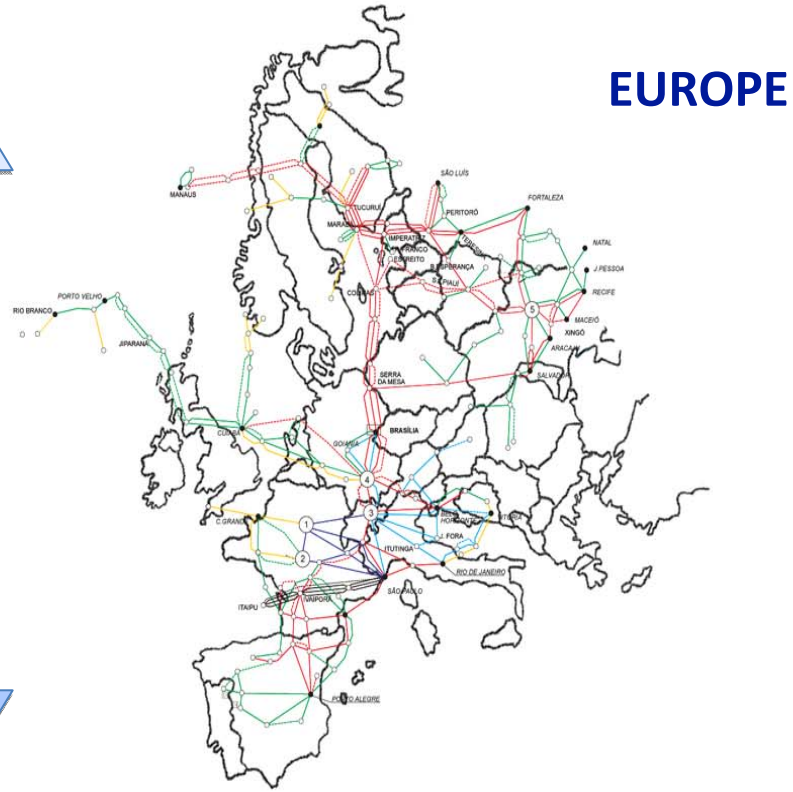
Ministry of Mines and Energy - BRAZIL
Secretariat for Energy Planning and Development
Energy Development Division

Tokyo – June, 2013

Brazilian Power Grid and General Information

BRAZIL

3,900 km



EUROPE

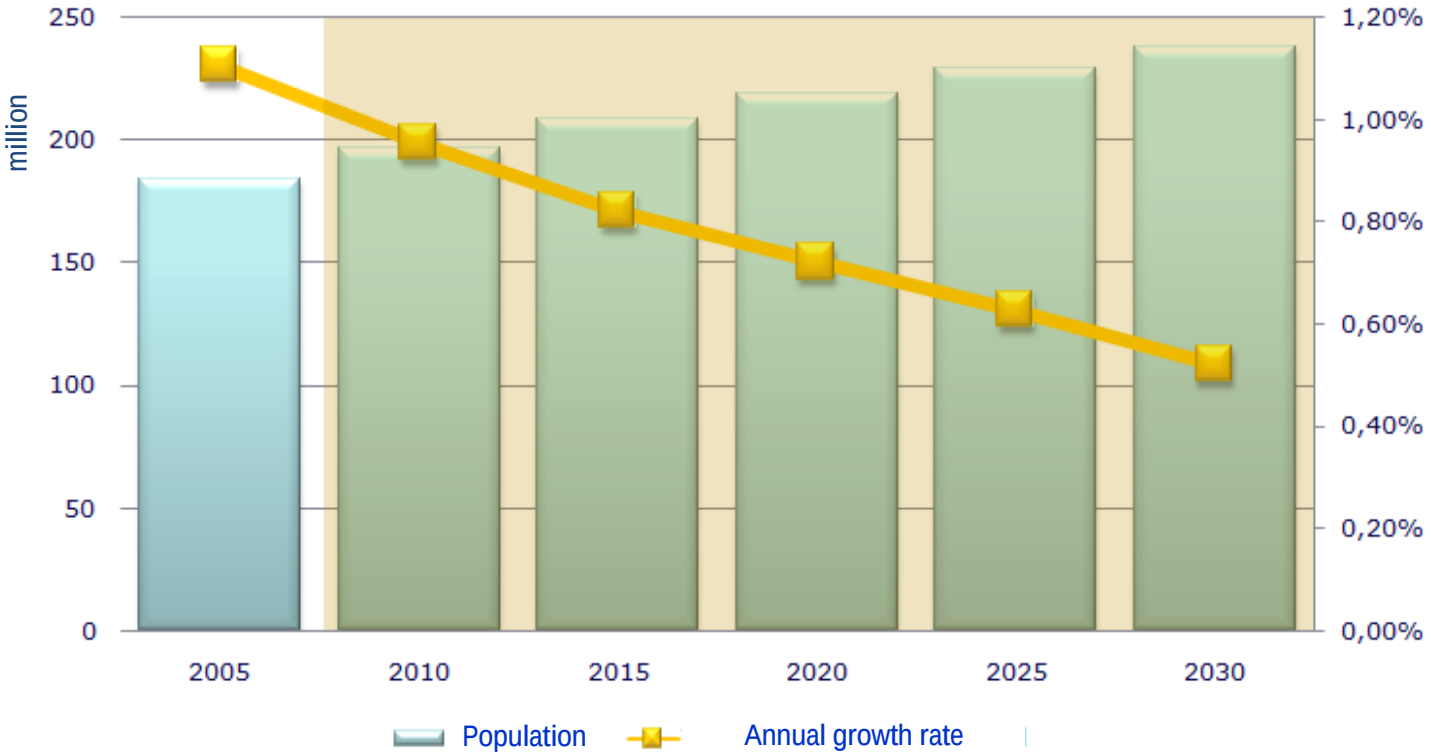
Brazil (2009)

- **Population:** 191 millions
- **GDP:** US$ 1,746 billions
- **EE Costumer unities:** 65.5 mi

- **Installed Capacity:** 112.5 GW
- **High Voltage Transmission:** 97,349 km
- **Electricity Consumption**: 426.0 TWh

Sources: BEN 2009, Resenha Energética 2010, PDE 2019, IBGE, ANP, MME, IPEAData

Demographic Projections



PER CAPITA INCOME

US$ [2005] per capita

2005	4,301	4,824
2030	9,125	

POPULATION

Million inhabitants

2005	185	53
2030	238	

Δ Population$_{2005\text{-}2030}$ = 53 million, comparable with

Spain (2008)
46 million

Northeastern region
(Brazil)
52 million

France
(2008)
65 million

Sources: IBGE, 2008 and PNE 2030

Guidelines for the Brazilian Energy Policy

- Energy Security
- Reasonable consumer tariffs
- Service availability for the entire population
- Regulatory framework stability
- Strengthening of planning
- Energy matrix diversification and renewables usage
- National energy integration
- National technological development
- Concern about social-environmental constraints

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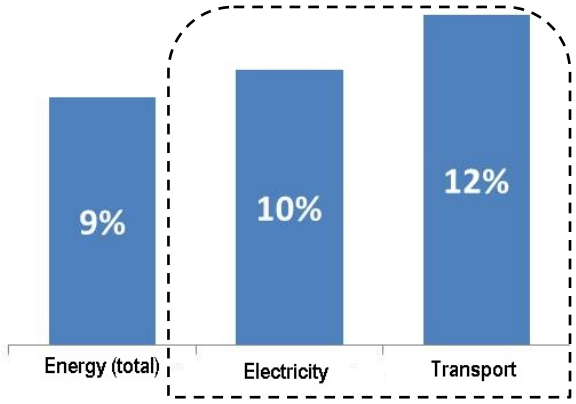
Building the future energy mix

Energy Efficiency

Role of Energy Efficiency for the reduction of energy demand: PNE 2030



PROCEL
Programa Nacional de Conservação de Energia Elétrica

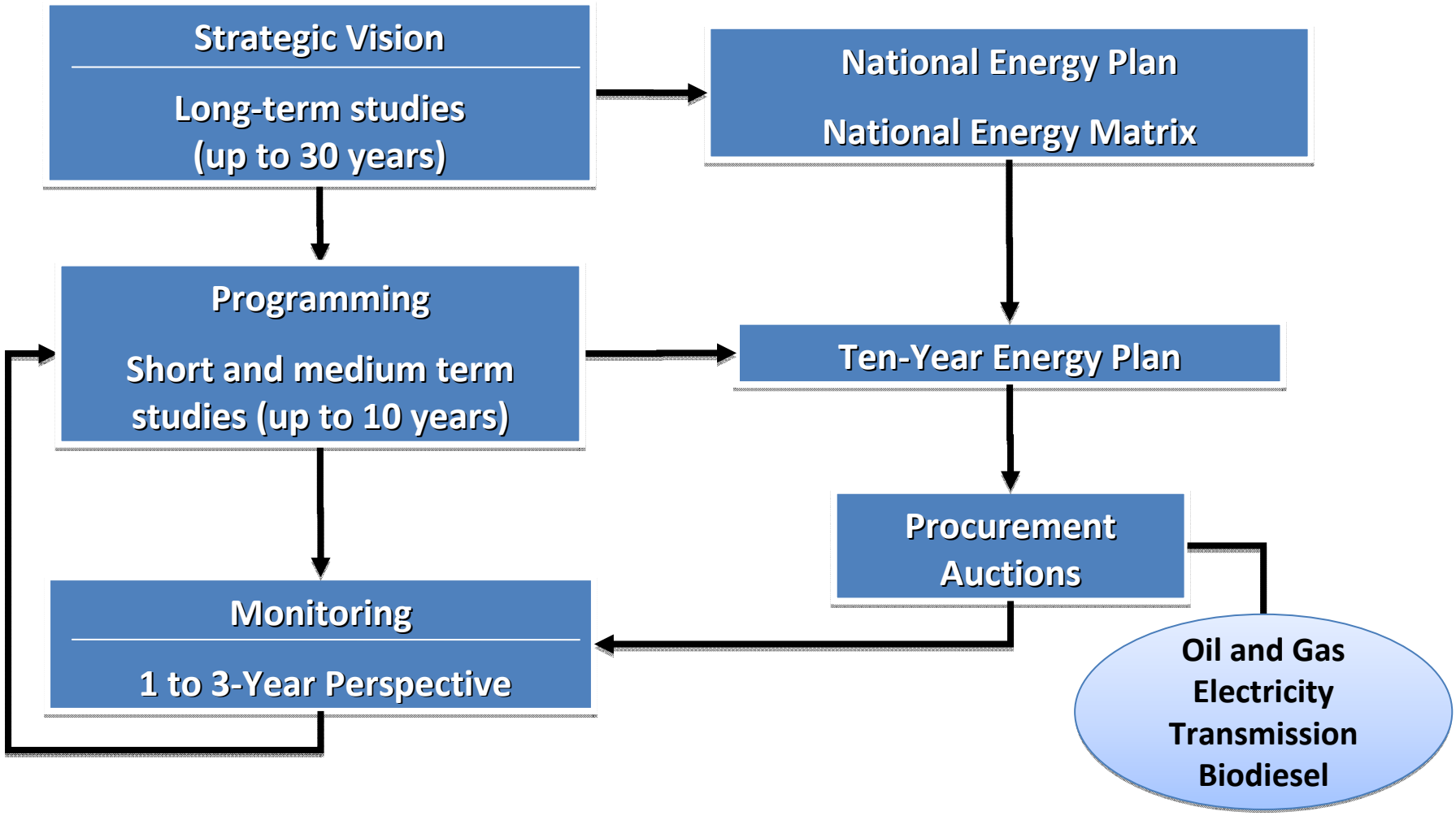
conpet
Programa Nacional de Racionalização do Uso dos Derivados do Petróleo e do Gás Natural

PBE
Programa Brasileiro de Etiquetagem

Technological Inovation

- Hidropower Platform
- Biofuels
- Bioeletricticity
- Hidrogen
- Urban Solid Wastes
- Solar PV
- Electric Power Transmission

Energy Planning



Energy Market

Electricity Generation

Competition in the Market

Transmission and Distribution

Competition in the Market

Regulated Market

Market Separation

Free Market

State-owned and private enterprises operate side-by-side

Centralized Dispatch optimized by the *National Power System Operator*

CCEE: Financial and Energy Accounting

Power Generation Expansion

Competition

Free Market
ACL

CL C

Freely Negotiated Prices

Regulated Market (ACR)
Procurement Auctions for the lowest energy tariff

D

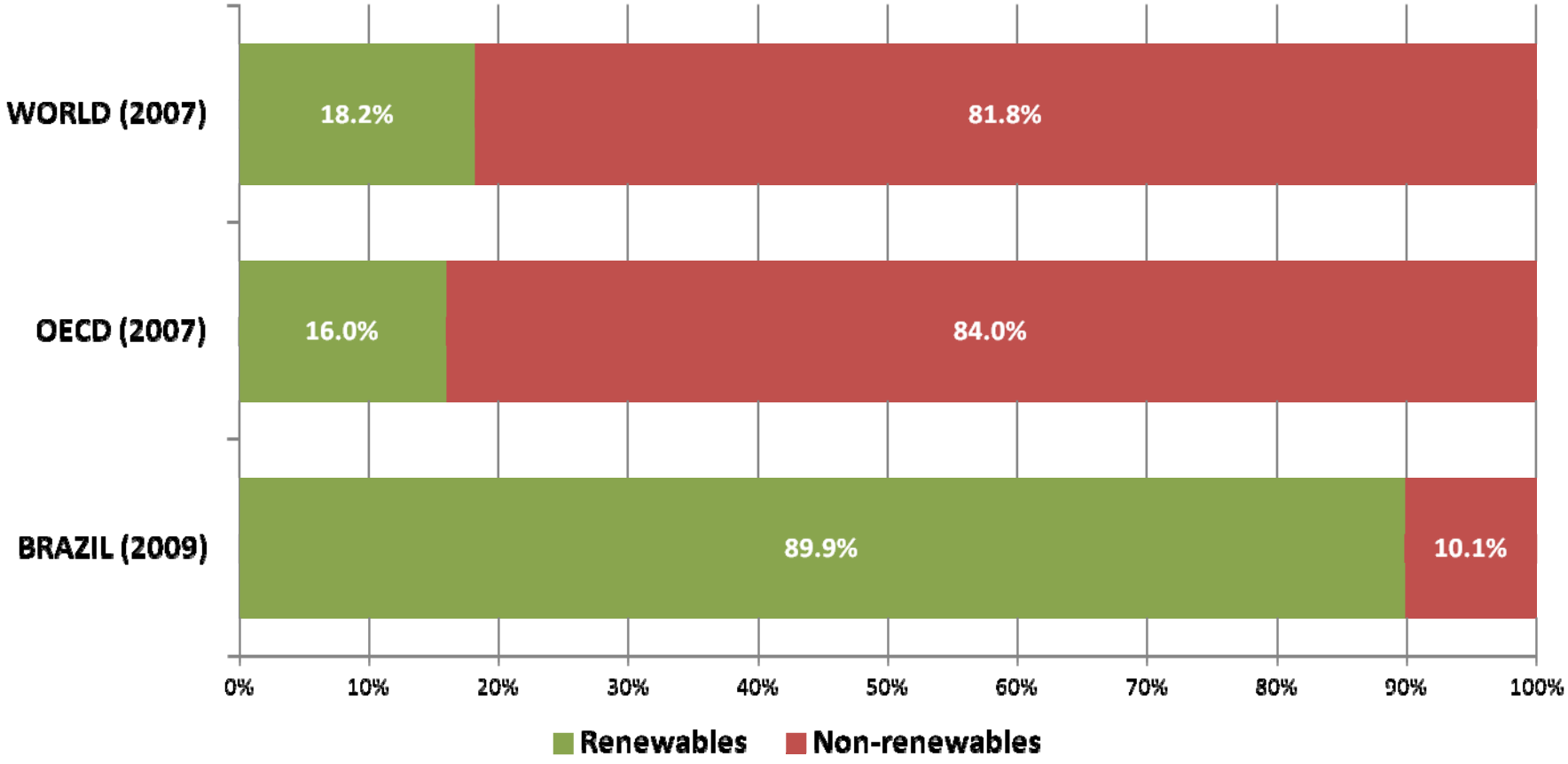
Prices set by Procurement Auctions

D = Distributors/ Eligible Consumers

CL = Free Consumers (above3 MW)

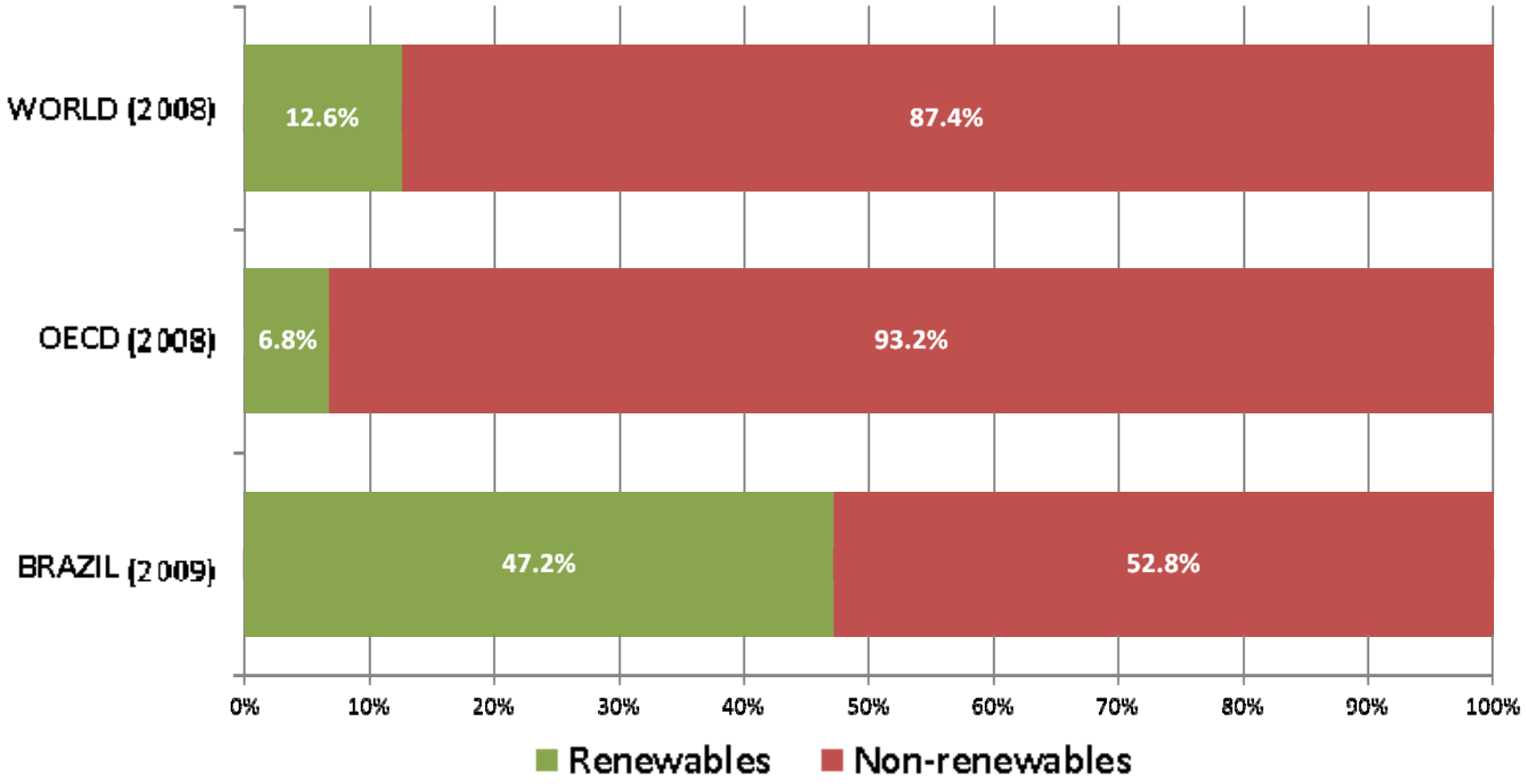
C = Energy Traders

RENEWABLE ENERGY in the ELECTRICITY MATRIX



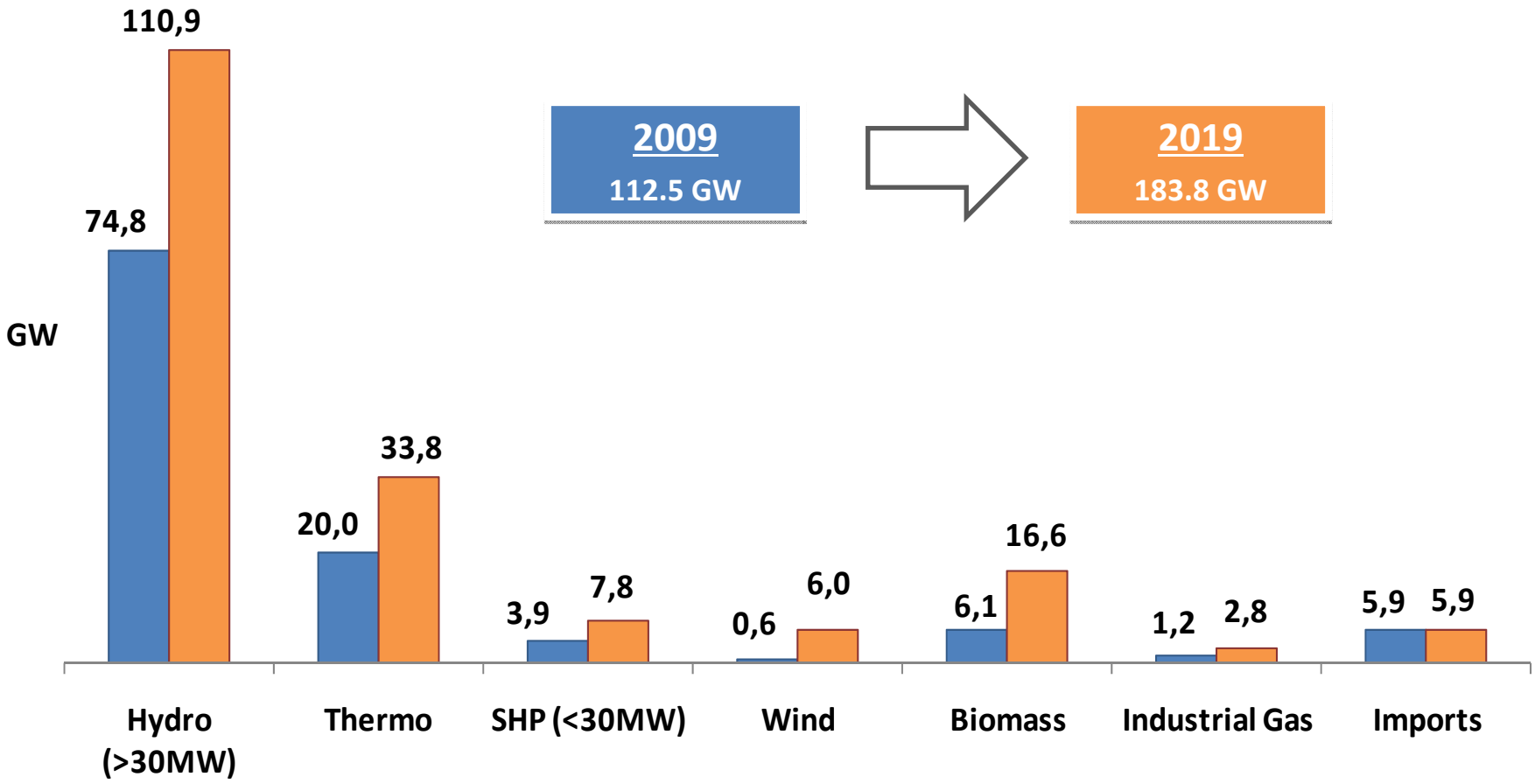
Sources: Brazilian Energy Review. 2010
Key World Energy Statistics. IEA, 2008

RENEWABLE ENERGY in the TOTAL MIX



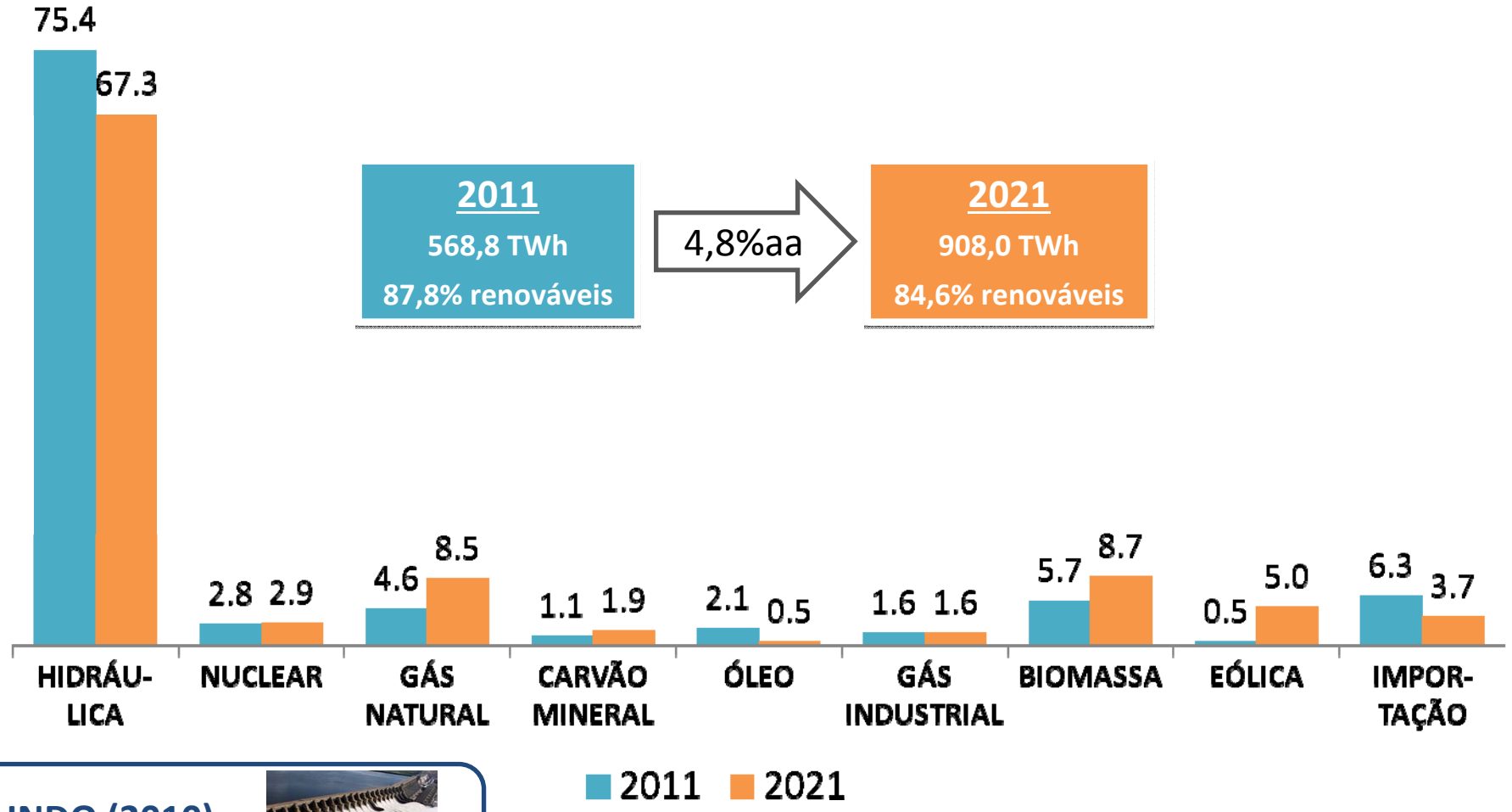
Fontes: Resenha Energética. MME, 2010
Key World Energy Statistics. IEA, 2008

Brazilian Electricity Supply Evolution



Source: MME/ PNE 2030, Brazilian Energy Review 2010.

Matriz de Oferta Interna de Energia Elétrica (%)



2011
568,8 TWh
87,8% renováveis

4,8%aa

2021
908,0 TWh
84,6% renováveis

MUNDO (2010)
-RENOVÁVEIS: 19%

Fonte: PDE 2021, IEA Data Services - World Energy Balances.

Expansão na Matriz Elétrica e Investimentos até 2021

Expansão da Capacidade Instalada do Sistema Interligado Nacional (GW)

Manutenção de expressiva participação de renováveis.

Fontes	2011	2016	2021	Incremento 2011-21	Participação na Matriz (%) 2011	2021
HIDRO (*)	83.6	98.2	116.8	33.2	71.8	64.1
PCH	4.6	5.4	7.1	2.5	3.9	3.9
BIOMASSA	7.7	9.6	13.4	5.7	6.6	7.4
EÓLICA	1.4	9.4	15.6	14.2	1.2	8.6
NUCLEAR	2.0	3.4	3.4	1.4	1.7	1.9
GÁS NATURAL	10.2	12.1	13.1	2.9	8.8	7.2
CARVÃO	1.8	3.2	3.2	1.4	1.5	1.8
ÓLEO	4.5	9.4	9.1	4.5	3.9	5.0
GÁS INDUSTRIAL	0.7	0.7	0.7	0.0	0.6	0.4
TOTAL	116.5	151.4	182.4	65.9	100.0	100.0

Investimentos em Energia 2011-2021

Mais de 1 trilhão de reais em 10 anos.

Setor	R$ bi	(%)
Energia Elétrica	**269**	**24,5**
Geração	*213*	*18*
Transmissão	*56*	*5*
Petróleo e Gás	**749**	**68,3**
Biocombustíveis	**79**	**7,2**
TOTAL	**1.097**	**100**

Fonte: PDE 2021

(*) Inclui importação (Itaipu-Paraguai)

Nota: não inclui autoprodutor cativo (que não usa rede pública) e não inclui sistemas isolados

Projects Planned for the next decade

Large Hidros

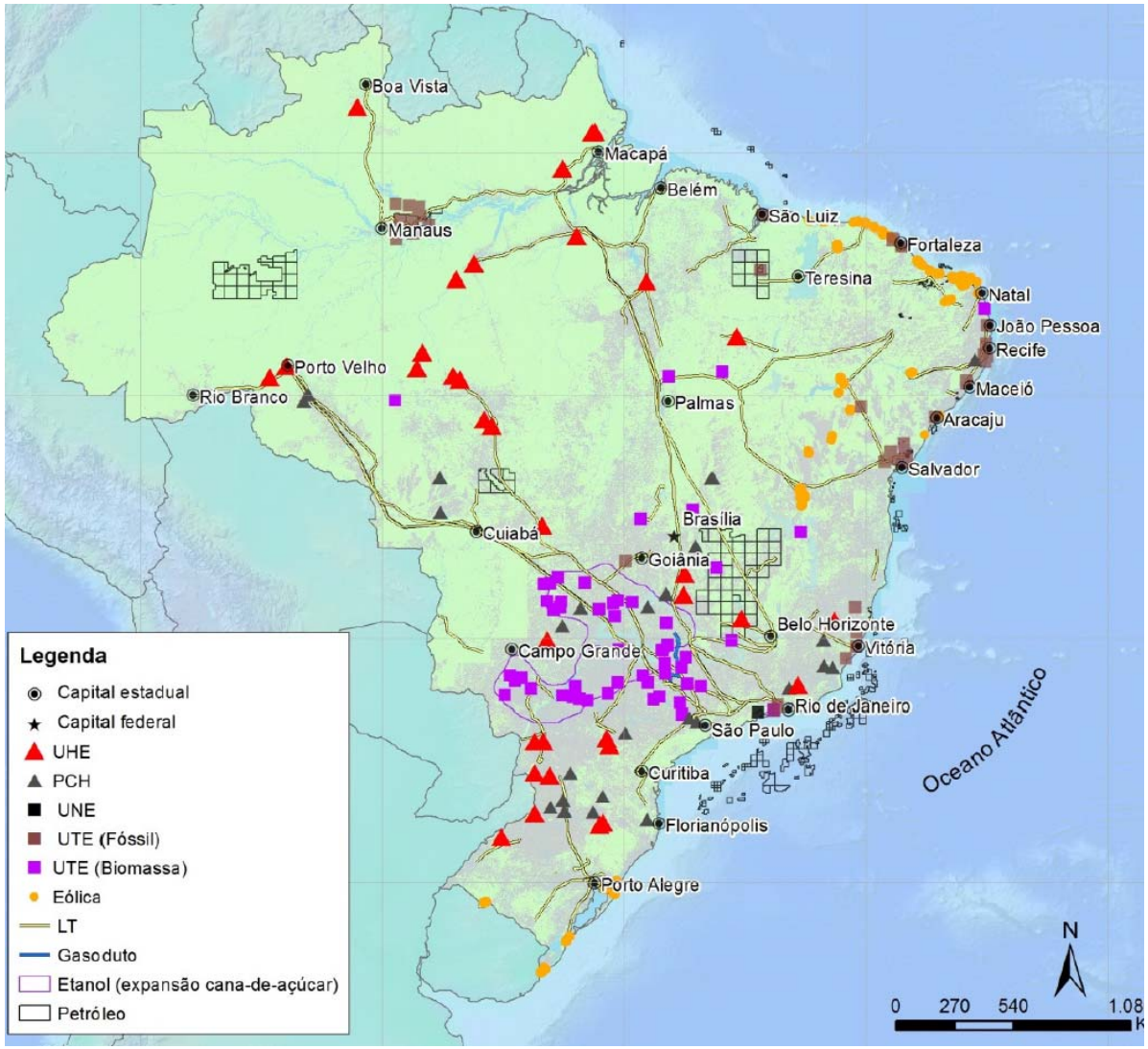
Mostly in the north (largest potential)

Biomass Thermos

Located in the Ethanol prodcution areal (Southeast and Midlde-west)

Wind farms

Seashore areas in the Northeas t and in the South



Fonte: PDE 2021.

Renewable Energy

Imperative of Sustainability

Costs and Constraints

Increasing financial costs of energy, on a long-term perspective, due to the exhaustion of more economical sources and social-environmental constraints

Change in Worldwide values

World opinion is increasingly favorable to the adoption of new patterns of energy production and consumption, compatible with human development and environmental protection

Renewable Sources

This context confirms that the strengthening of policies to promote renewable alternative energy sources, as well as energy efficiency, is necessary to achieve a virtuous cycle between energy expansion, development and environmental sustainability

Hydropower Potential

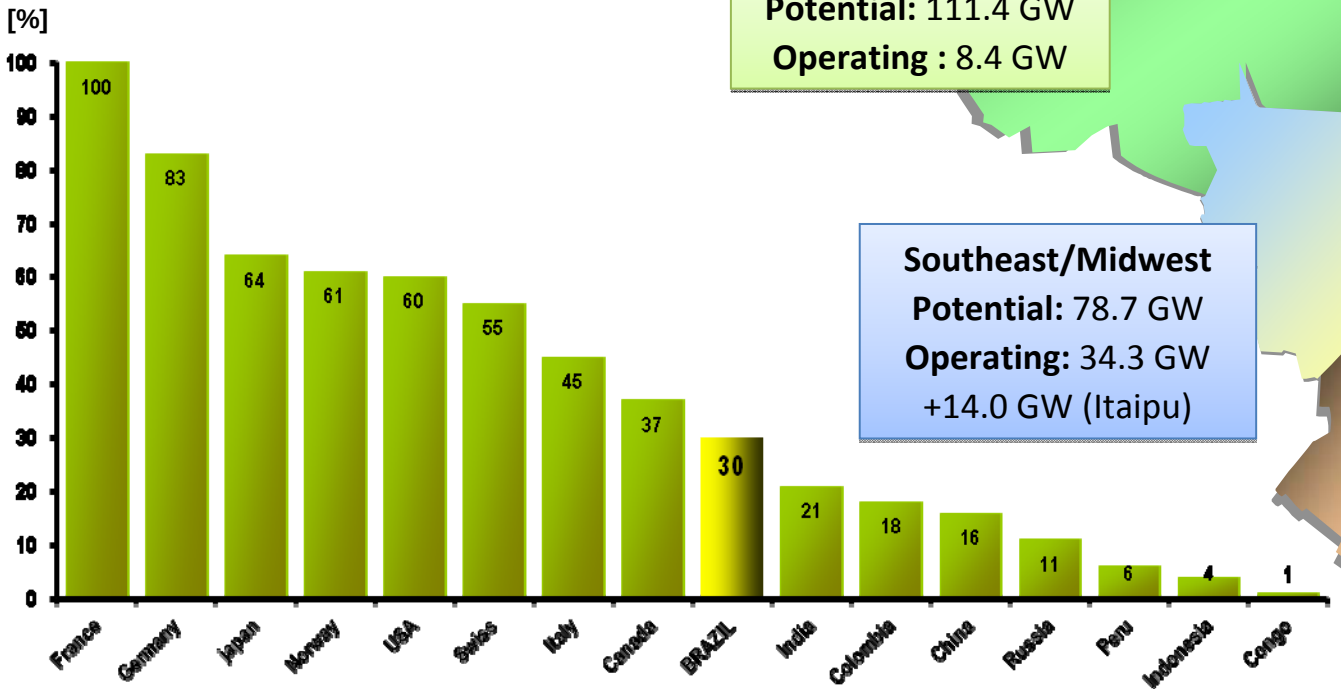
Brazil
Potential: 258.4 GW
Operating: 30%

North
Potential: 111.4 GW
Operating : 8.4 GW

Northeast
Potential : 26.3 GW
Operating : 10.9 GW

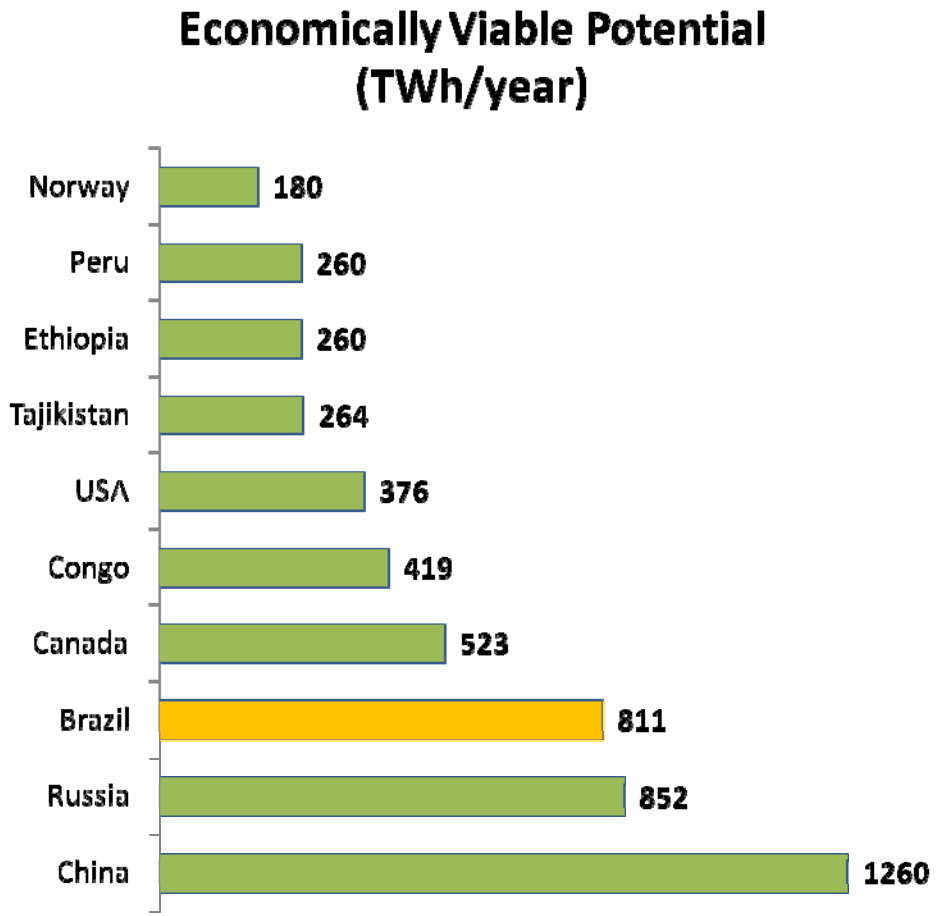
Southeast/Midwest
Potential: 78.7 GW
Operating: 34.3 GW
+14.0 GW (Itaipu)

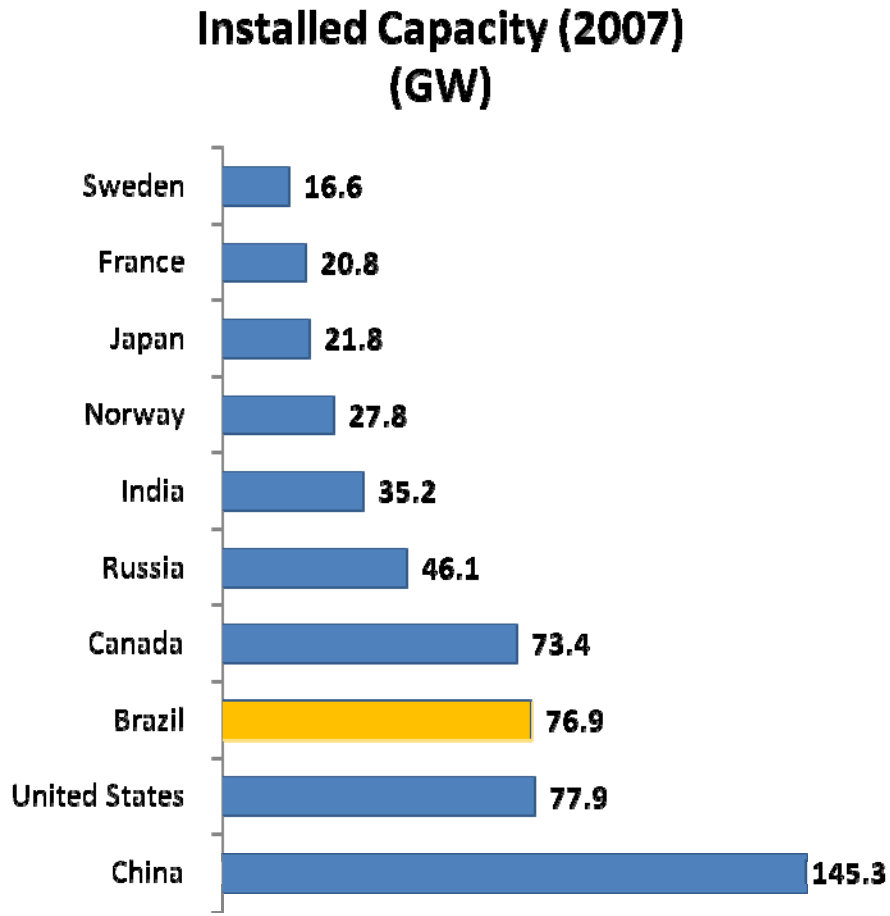
South
Potential: 42.0 GW
Operating : 12.9 GW



World hydropower developed potential

Hydroelectricity in the World – Top 10





Source: Manual do Inventario, 2005, EIA/DOE - International Data

Hydropower Potential

- We still have a substantial hydropower potential to be developed, mainly in the Amazon Region. Environmental concerns and restrictions make this development a challenge. Brazil is facing it.

- A new concept of lower impact hydropower plant construction has been developed to face environmental restrictions: **Platform Power Plants** (*Usinas Plataforma*). This concept, inspired by offshore oil platforms, is very suitable for hydro applications in the Amazon Region.

- Brazil has an extensive experience on hydropower plants. This can be an outstanding area of partnership between our countries.

Incentive Policies for Renewables

- National Program of Incentives for Alternative Sources – Proinfa (Law 10438/02)
- Tax reduction regarding Transmission and Distribution Systems Use (Law 9427/96)
- Merchandise Circulation Tax Exemption (ICMS arrangement 101/97)
- Special Incentive Regime for Infrastructure Development – REIDI (Decree 6144/07)
- Distributed Generation – GD (Law 10848/04)
- Contracts with Special Consumers (Law 9427/96)
- R&D Exemption (Law 9991/00)
- Subrogation of the Fuel Cost Account – CCC: Only Isolated System (Law 9648/98)
- Clean Development Mechanism: Carbon Credits
- ANEEL 482/2012

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- Clean Development Mechanism: Carbon Credits
- **ANEEL 482/2012**

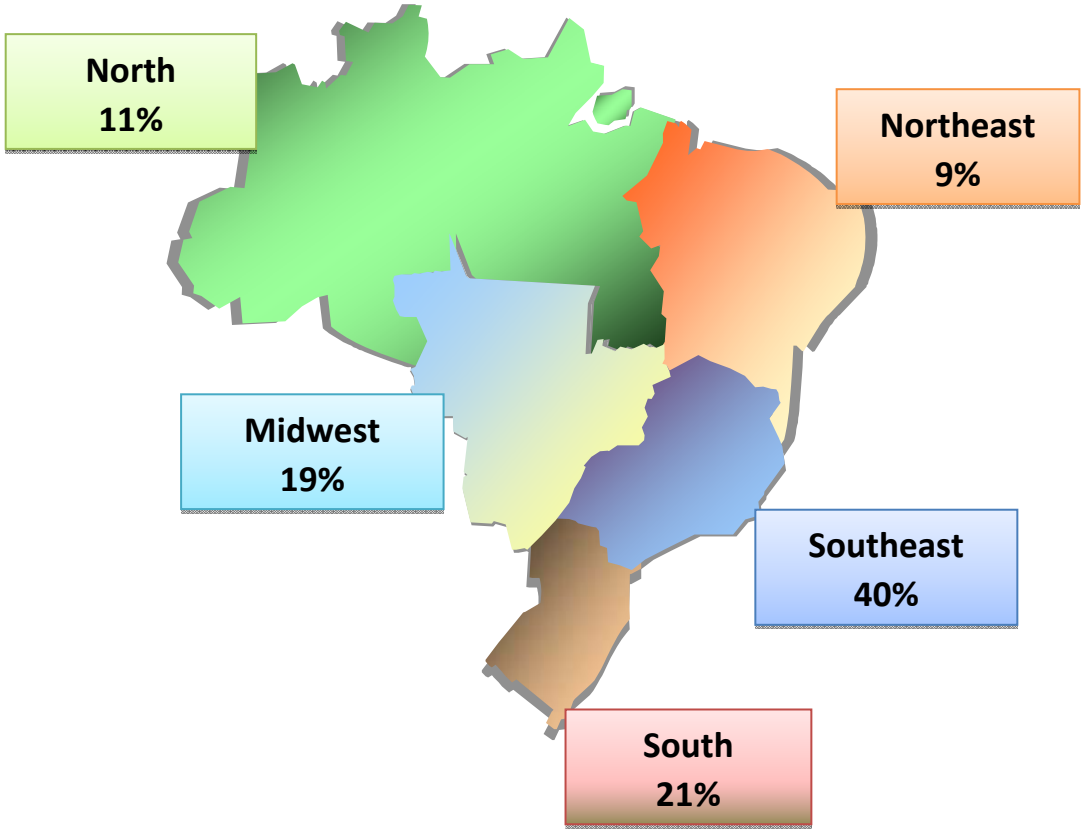
Small Hydropower Plant (SHP) – 1 to 30MW

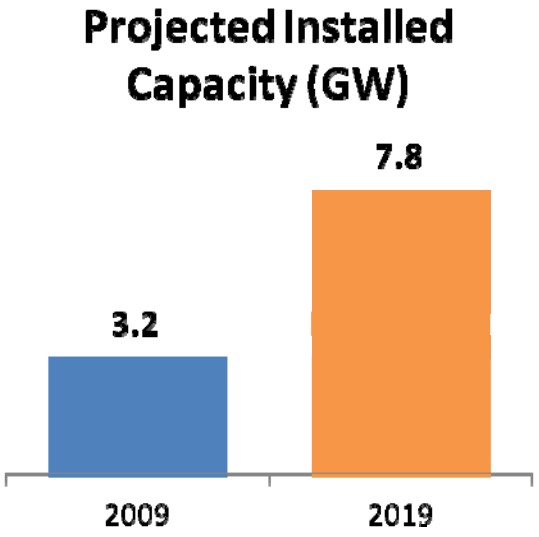
Marmelos Zero **Hydro Plant – MG – 1889 – 4 MW**

Santa Rosa **Power Plant – RJ – 30 MW**

- Brazil has an estimated potential of around 17,5 GW of SHP
- SHP in Brazil has fully developed technology and a competitive price
- Environmental restrictions are also the challenge to implement projects

Small Hydropower Potential
17,5 GW

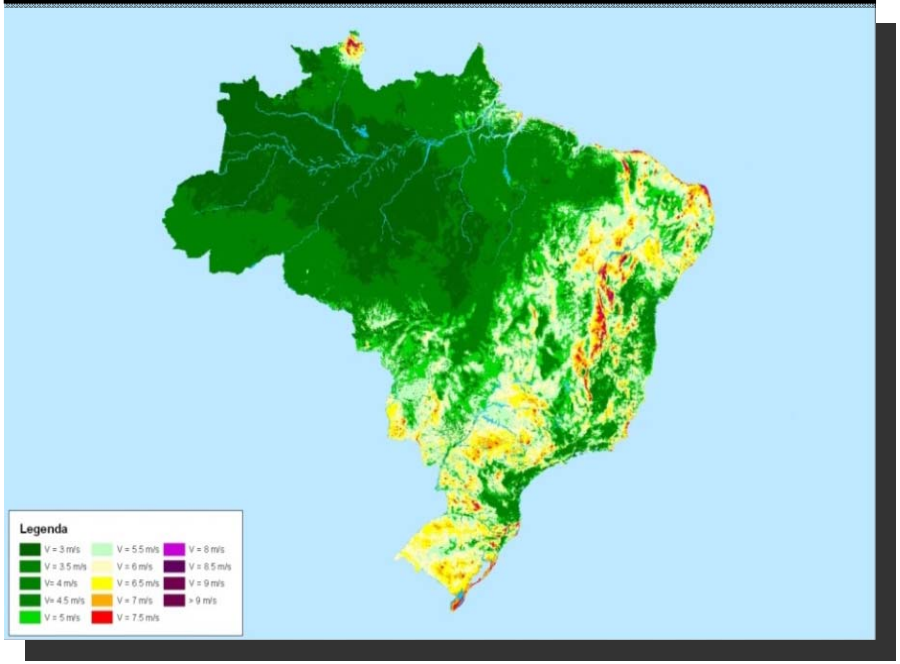




Source: PDE 2019 and PNE 2030

Wind Power Potential

At 50m altitude – 0.5 MW turbines



Estimated Wind Power Potential
143 GW
272.2 TWh/year

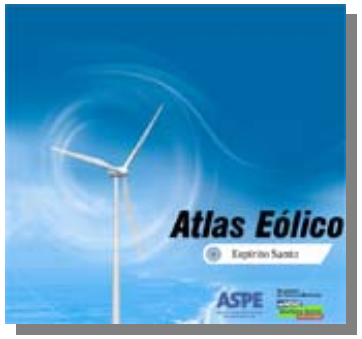
At 100m altitude – 2 MW turbines

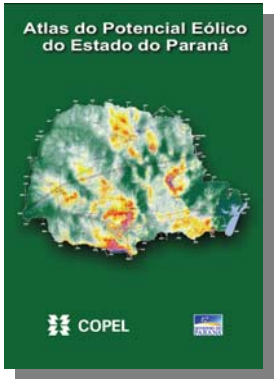
Estimation under development
Expected Potential around 300 GW

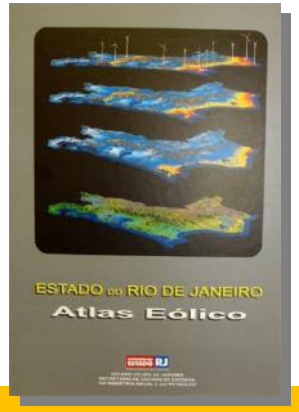
Source: CRESESB/CEPEL, 2001.

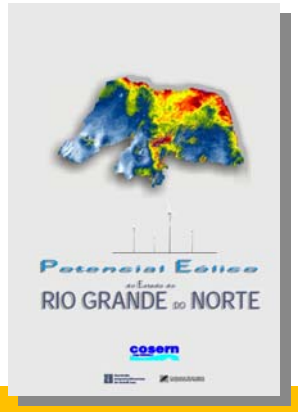
Wind Atlas from the States

- **Alagoas**
  http://www.desenvolvimentoeconomico.al.gov.br/minas-e-energia/mapa-eolico/
- **Bahia**
  http://www.coelba.com.br/
- **Ceará**
  http://www.seinfra.ce.gov.br/
- **Espírito Santo**
  http://www.aspe.es.gov.br/atlaseolico/
- **Minas Gerais**
  http://www.cemig.com.br/atlas_eolico_2010/index.htm
- **Paraná**
  http://www.copel.com/download/mapa_eolico/Atlas_do_Potencial_Eolico_do_Estado_do_Parana.pdf
  http://www.copel.com/download/mapa_eolico/Mapa_do_Potencial_Eolico_do_Estado_do_Parana.pdf
- **Rio de Janeiro**
  Governo do Estado - Secretaria de Estado de Energia, da Indústria Naval e do Petróleo
- **Rio Grande do Norte**
  http://www.cosern.com.br/ARQUIVOS_EXTERNOS/PDF/mapa_eolico.pdf
- **Rio Grande do Sul**
  http://www.semc.rs.gov.br/index.php?menu=atlaseolico









Sangradouro Wind Farm, RS - Brazil

Wind Energy

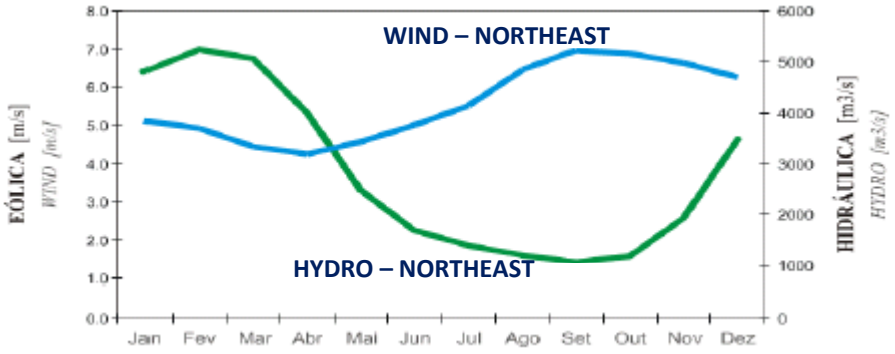
❖In the latest years wind has been experimenting large growth rates in Brazil, following a combination of governmental policies of incentives and a strong interest of enterprises.

❖ In an auction at December 2009, 1,805 MW were purchased (148,00 R$/MWh); at August 2010, 2.047,8 MW (134,86 R$/MWh); August 2011, 1.928,8 MW (99,5 R$/MWh . So, the price of wind energy is now fully competitive in Brasil.

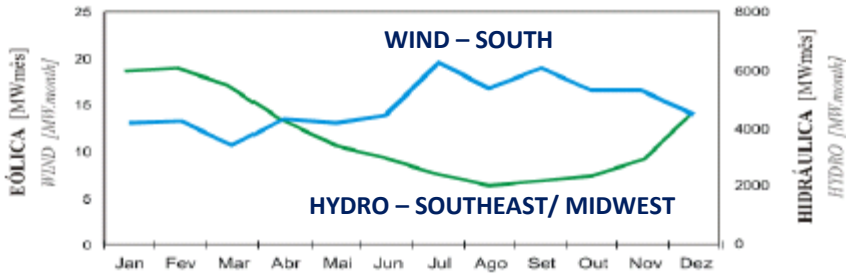
❖ The combined utilization of Hydro and Wind, improves the energetic potential of both sources due to their seasonal complementary characteristics.

Regional Complementarities

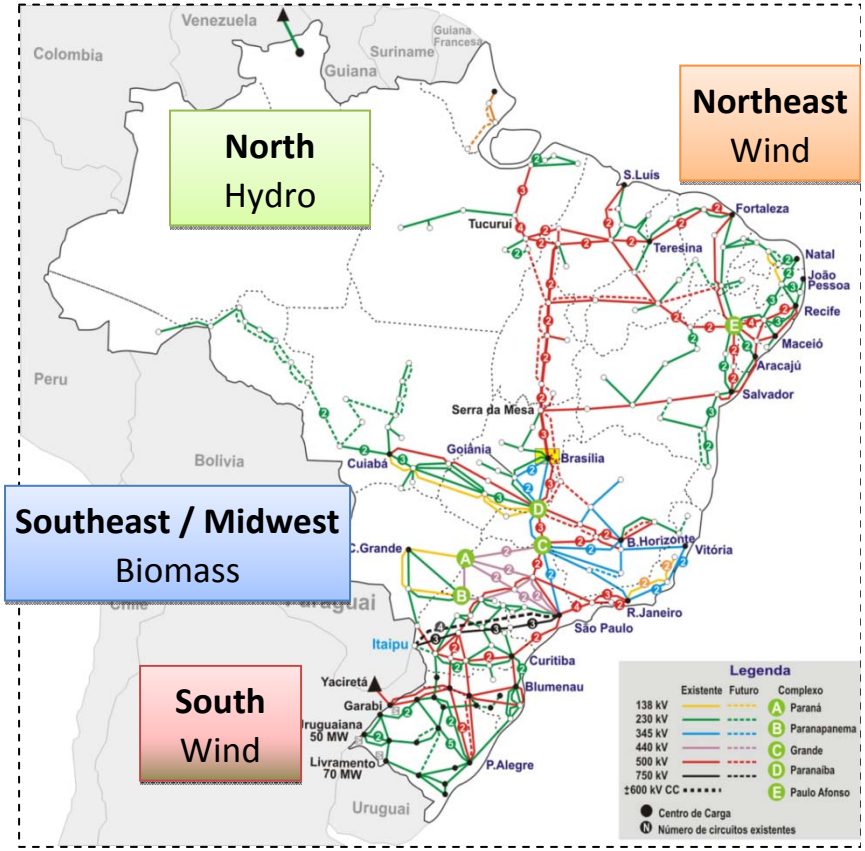
Northeast Region



South / Southeast Regions

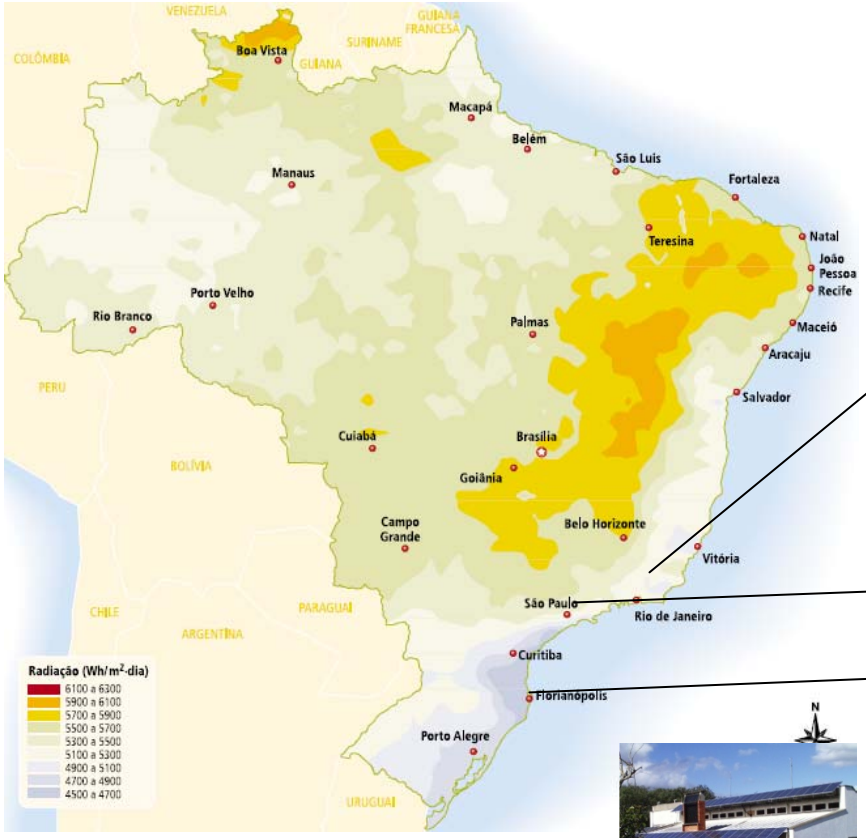


Regional Complementarities



Source: Associação Brasileira de Energia Eólica.

Brazilian Solar Power: Results



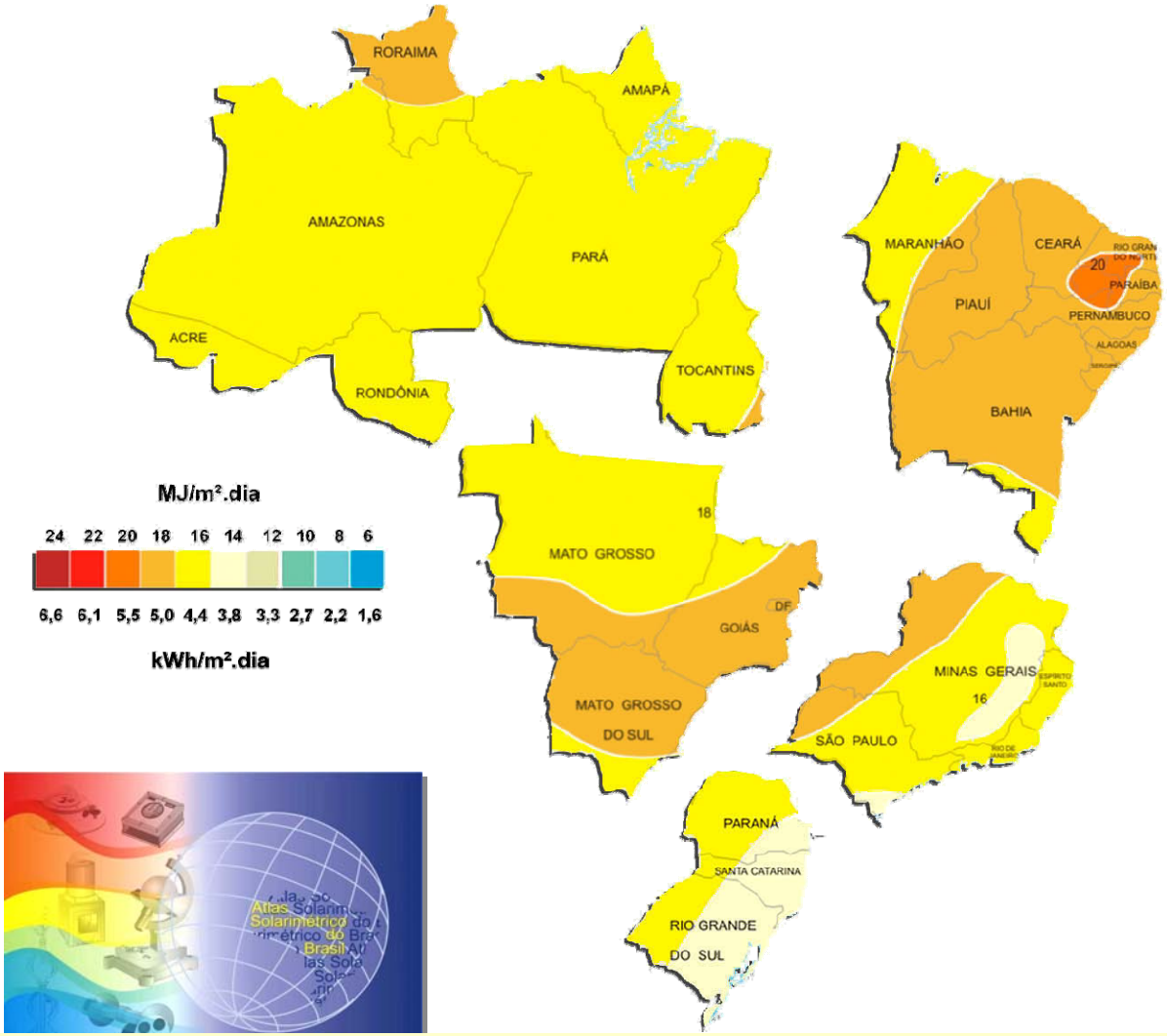
Solar Atlas - Brasil

- **Brazilian Solarimetric Atlas (UFPE, CHESF)**
  - Developed in 2001 under the GTEF (Working Group on Photovoltaic Solar Energy) in order to eliminate the deficiencies related to obtaining solarimetric data measured in the country.
  - The maps were interpolated from the data measured on surface at several stations througout the country relying on instruments such as, actinograph and pyranometers. Period: from 1960 to 1990.

- **Brazilian Atlas of Solar Energy (INPE, UFSC)**
  - Developed in 2006 under the project SWERA (Solar and Wind Energy Resource Assessment) with the goal of creating a database of solar radiation involving the entire Brazilian territory using satellite imagery.
  - The maps were developed from a satellite model specific to the country called Brazil-SR. Period: from 1995 to 2005.

- **DNI (direct normal irradiation) maps for the brazilian semiarid region (CEPEL)**
  - Developed in 2012 as part of the characterization study of sites for deployment of CSP pilot plant in the semiarid region, under the agreement CEPEL / MME.
  - DNI was calculated from the measurement of duration of sunshine at meteorological stations INMET and then applied an interpolation model available in GIS platform. Period: from 2000 to 2009.

Brazilian Solar Potential



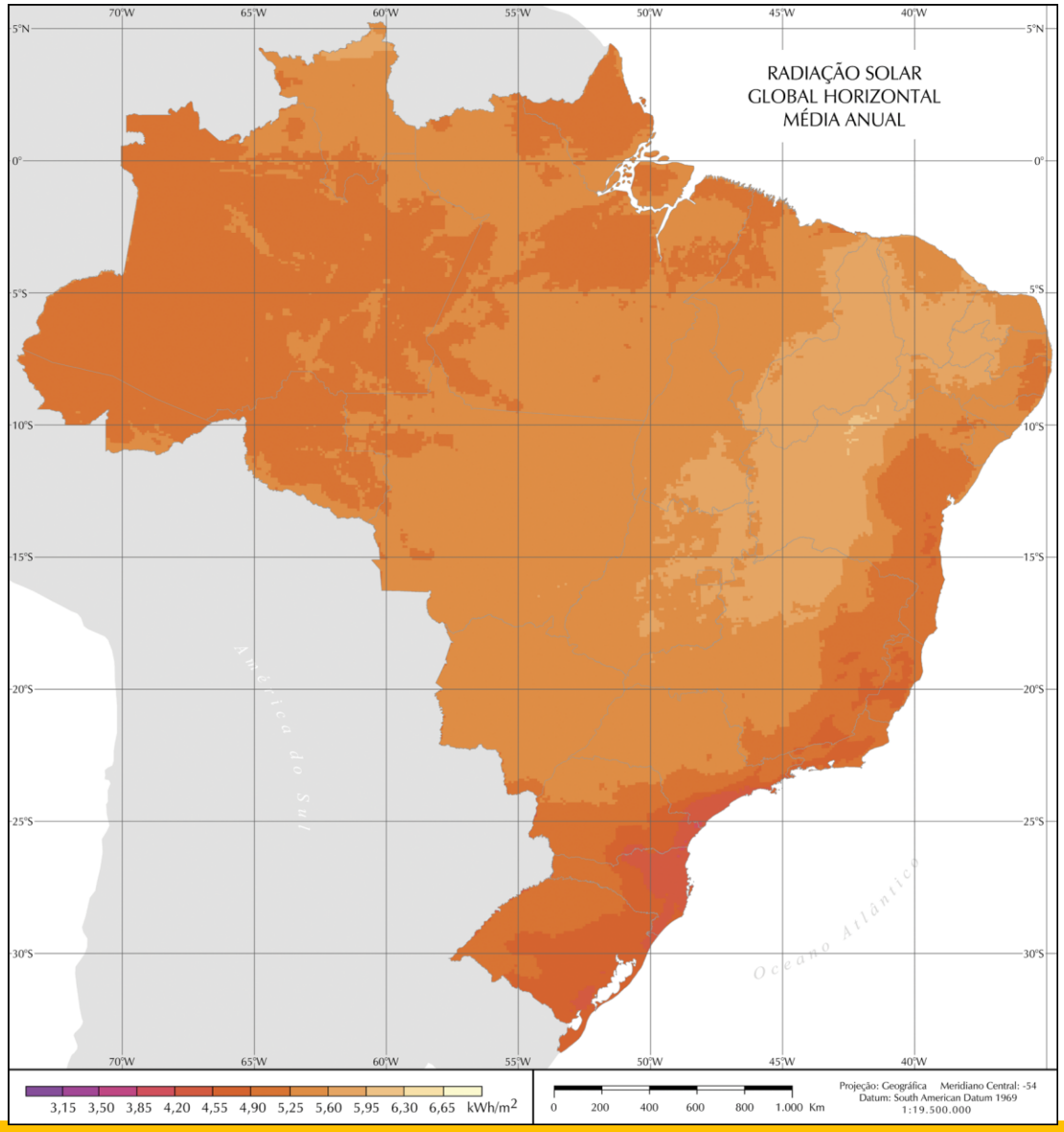
Annual Global Radiation (MJ/m².day)

Interpolation method using global radiation from several country meteorological stations

Instruments: actinographs (most) and pyranometers

Measurement Period: 1960 to 1990

Brazilian Solarimetric Atlas – UFPE/CHESF – 2000



Annual Global Radiation (kWh / m².day)

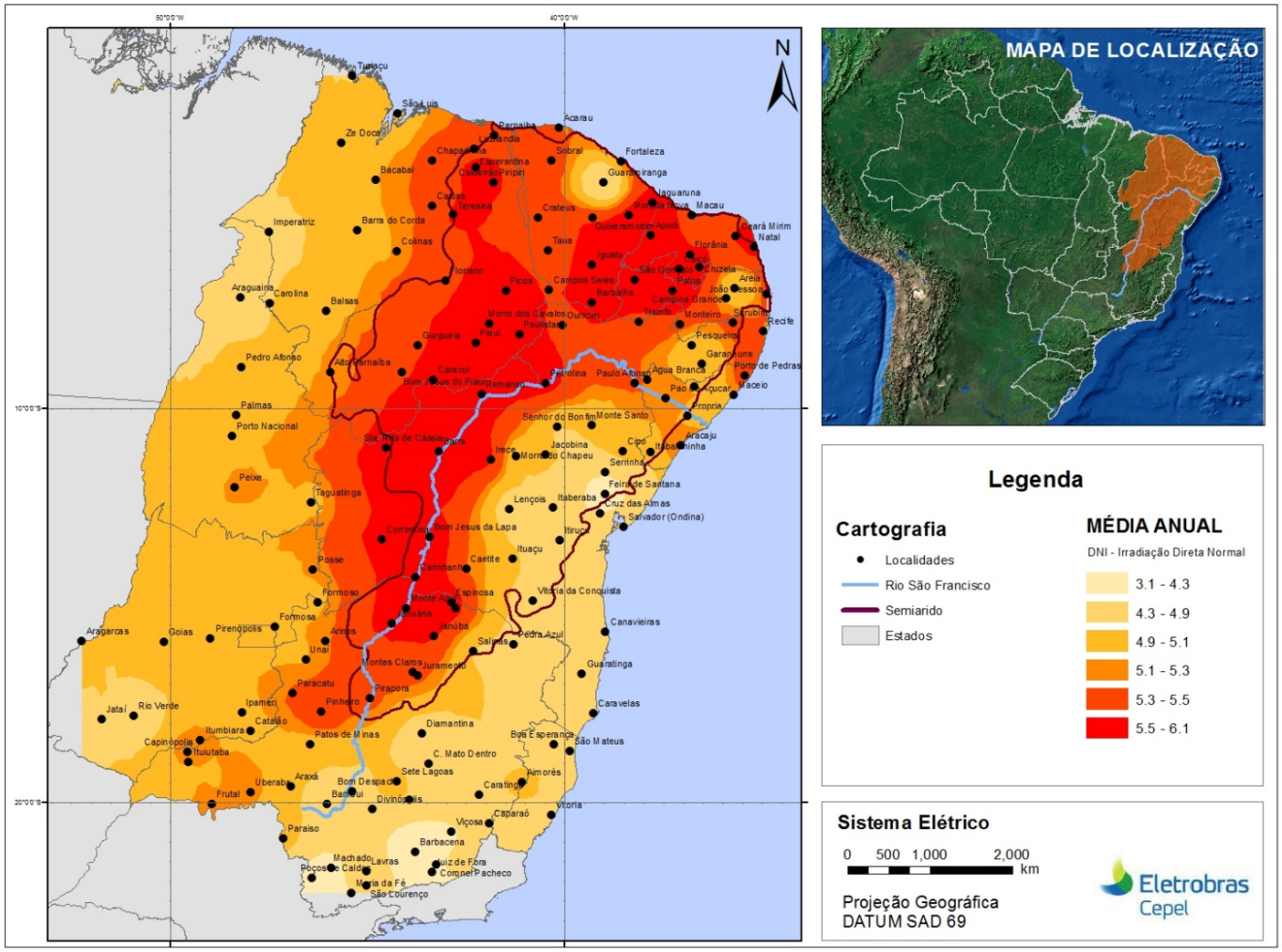
Global solar radiation estimated from satellite data.

Modelo BRASIL-SR

Measurement Period: July1995 to December 2005

Brazilian Atlas of Solar Energy
CPTEC / INPE ,LABSOLAR / UFSC

projeto SWERA – 2006



Direct Normal Solar Radiation (kWh/m².day)

Direct normal solar radiation estimated from insulation hours of approximately 150 meteorological stations and applying classical mathematic models

Measurement period: Jan. 2000 to Dec. 2009

CEPEL, 2011

Brazilian Solar Power: Results

Capacidade de Geração do Brasil

USINAS do tipo UFV em Operação					
Usina	Potência Outorgada (kW)	Potência Fiscalizada (kW)	Destino da Energia	Proprietário	Município
Araras - RO	20,48	20,48	REG	100% para Fundação de Amparo à Pesquisa e Extensão Universitária	Nova Mamoré - RO
Tauá	5.000	1.000	REG	100% para MPX Tauá Energia Solar Ltda.	Tauá - CE
IEE	12,26	12,26	REG	100% para Instituto de Eletrotécnica e Energia	São Paulo - SP
UFV IEE/Estacionamento	3	3	REG	100% para Instituto de Eletrotécnica e Energia	São Paulo - SP
Embaixada Italiana Brasília	50	50	REG	100% para Embaixada Italiana em Brasília	Brasília - DF
PV Beta Test Site	1,70	1,70	REG	100% para DuPont do Brasil S.A	Barueri - SP
Pituaçu Solar	404,80	404,80	REG	100% para Superintendência dos Desportos do Estado da Bahia	Salvador - BA
Aeroporto Campo de Marte	2,12	2,12	REG	100% para Empresa Brasileira de Infra-Estrutura Aeroportuária	São Paulo - SP
Tanquinho	1.082	1.082	REG	100% para SPE CPFL Solar 1 Energia S.A.	Campinas - SP
Silva Neto I	1,70	1,70	REG	100% para João Bento da Silva Neto	Florianópolis - SC
Terra do Sol IX	5.000	5.000	REG	100% para Bioenergy - Geradora de Energia S.A	Oliveira dos Brejinhos - BA
PGM	6,58	6,58	REG-RN482	100% para PGM Suporte em Tecnologia Ltda - EPP	Uberlândia - MG
Solaris	1,04	1,04	REG	100% para Solaris Tecnologia Fotovoltaica Indústria Comercio e Serviço Ltda. - EPP	Leme - SP
Total: 13 Usina(s)			Potência Total: 7.585,68 kW		

Legenda	
APE	Autoprodução de Energia
APE-COM	Autoprodução c/ Comerc. de Excedente
COM	Comercialização de Energia
PIE	Produção Independente de Energia
REG	Registro
REG-RN482	Registro mini micro Geradores RN482/2012
SP	Serviço Público

Photovoltaic

❖ The PV market is showing signals of positive changes in Brasil:

- Larger projects being implemented (MW scale);
- New Regulatory Framework – DG – ANEEL 482/2012
- "120 Proofs" Pilot Project involving government, utilities, university and research centers for grid connected PV in Brasil.
- It is an R&D project aiming to establish conditions and assess the consequences from the insertion of PV based distributed low voltage generation systems on dwelling roofs;
- Wind energy successful precedent can influences the decision makers;
- Growth importance of controlling greenhouse gas emissions in the world ;

Solar Energy: Photovoltaic

- Photovoltaic (PV) seems to be the natural solution for the electrification of small communities far from the power grid.

- Grid connected applications, helping to feed the cities, can become economically competitive as soon as prices fall.

- Brazil does not produce PV modules, in industrial scale.

- Producing PV equipment in Brazil – lower CO_2 emissions due to clean electricity matrix.

Brazilian Solar Power: Discussions

- Brazil is one of the world's greatest metal-grade silicon producers

but...

- Efficient Solar Panels require solar-grade silicon

and...

- Brazil has no significant solar-grade production

so...

- National and International companies are welcome to invest on solar-grade silicon and solar panel production

Biomass Potential

Source	In Operation	Projected for 2030
Sugarcane Biomass	271 plants 4,079 MW	6,571 MW
Urban Waste	-	1,300 MW
TOTAL	4,079 MW	7,871 MW

- **Projected values may increase due to technological developments and market behavior (ethanol demand)**

Cogeneration potential from sugarcane biomass	**05 years: 12.315 MW** **10 years: 22.315 MW**

Sources: PNE 2030; PDE 2010-2019

Biomass: Power Generation

❖Until 2019, the installation of power generation capacity with sugarcane bagasse is estimated in 16.6 GW.

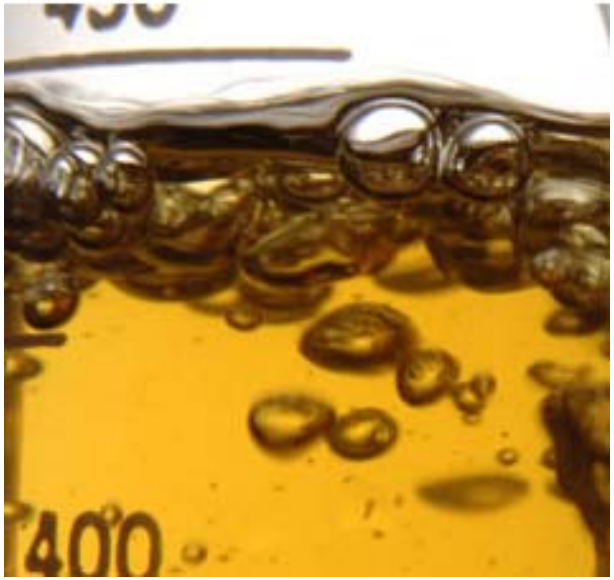
❖ This value can be higher depending on technological and market evolution. Other sources of biomass can be included as soon as their economical and technological potential is proved.

Biomass: Ethanol

❖ The productivity of sugarcane ethanol in Brazil is the highest in the world (6,800 l/ha).

❖ Brazil has 430 million ha (1 ha = 10,000 m^2) of agricultural land, and just 63 million ha are already occupied.

❖ Brazil has more than 30 years of expertise with ethanol as fuel, which gives a natural leadership on this area.



Biodiesel

- **Dec. 2004**: Launch of the National Program for the production and use of Biodiesel
- Brazil is already the world's 3rd largest consumer (after Germany and France)
- 82% of production capacity holds the **Social Fuel Seal** (Selo Combustível Social)
- 52 thousand families of small crop growers directly benefited in 2009
- Accomplished in 2010: **obligatory addition of 5% of biodiesel on fossil diesel**
- **US$ 343 million directed to familiar agriculture production of oil seeds in 2009**

A AGRICULTURA FAMILIAR PARTICIPA
BIODIESEL
COMBUSTÍVEL SOCIAL

Final Remarks

❖ Hydro will keep its first place at the electricity matrix, but new sources are coming.

❖ New renewable sources are approaching the prices of conventional sources. This, combined with environmental concerns, will drive to the increasing participation of them in the energy matrix, higher than conservative nowadays forecasts.

❖ Improve the knowledge of renewable potential resources is a permanent task.

❖ Partnership: International cooperation can drive to a higher degree of reliability and lower costs on data acquisition and processing. This can be profitable and bring benefits for all countries.

MINISTRY OF MINES AND ENERGY

THANKS!

http://www.mme.gov.br/

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