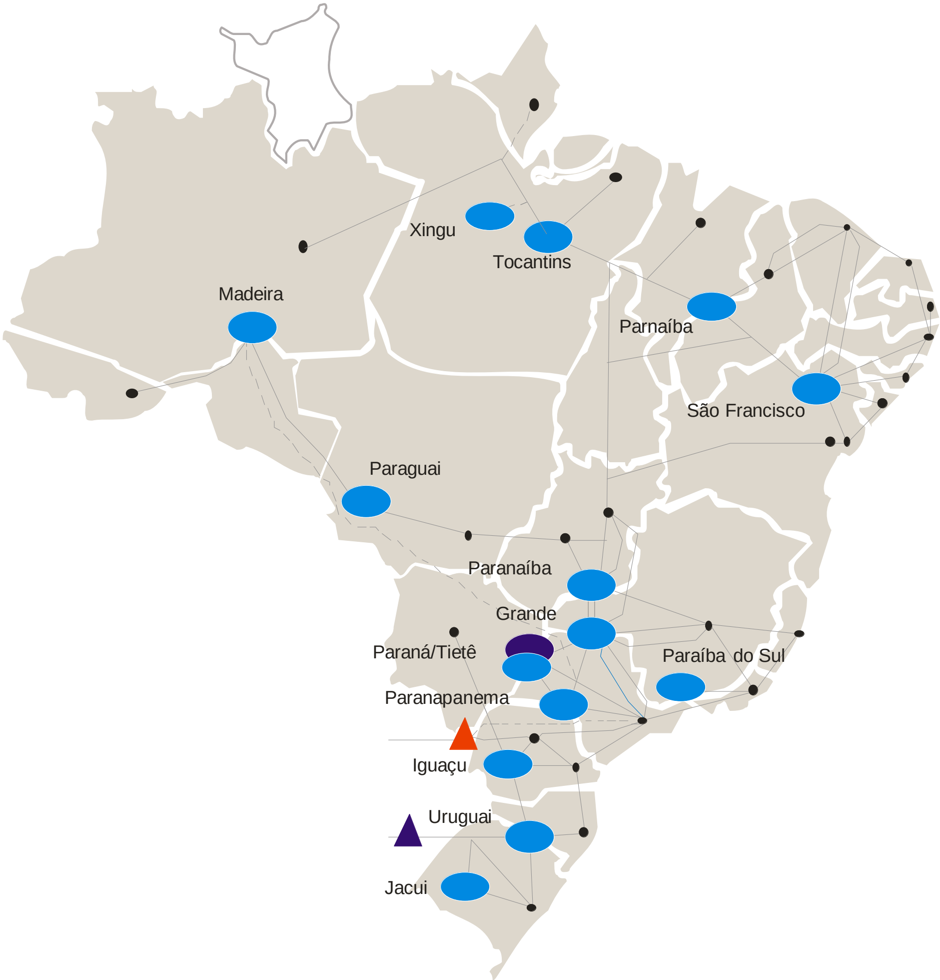
The Electric Power System

- Brazil -

Basic facts

- ❑ Area: 851.600.000 ha
- ❑ Population: 213 665 456
- ❑ Number of electricity consumers: 80 621 000
- ❑ Number of TSOs: 01
- ❑ Number of DSOs: 0
- ❑ Peak load: 84 500 MW
- ❑ Average interruption of electricity: 9 000 MW
- ❑ Scattered load and long connection lines
- ❑ Transfer of large amounts of energy between different regions

Global map of the grid and of its interconnections

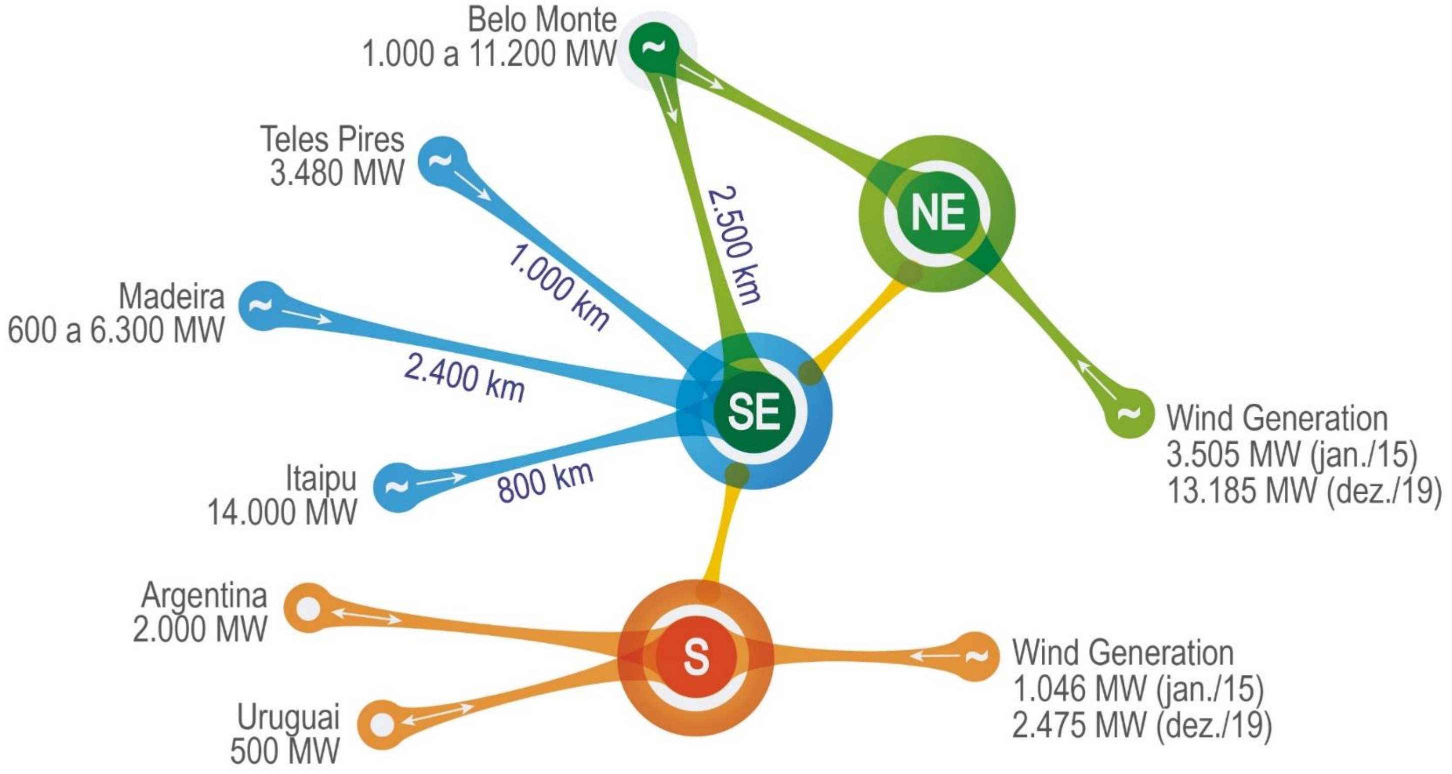


Charactheristics of Hydro Production:

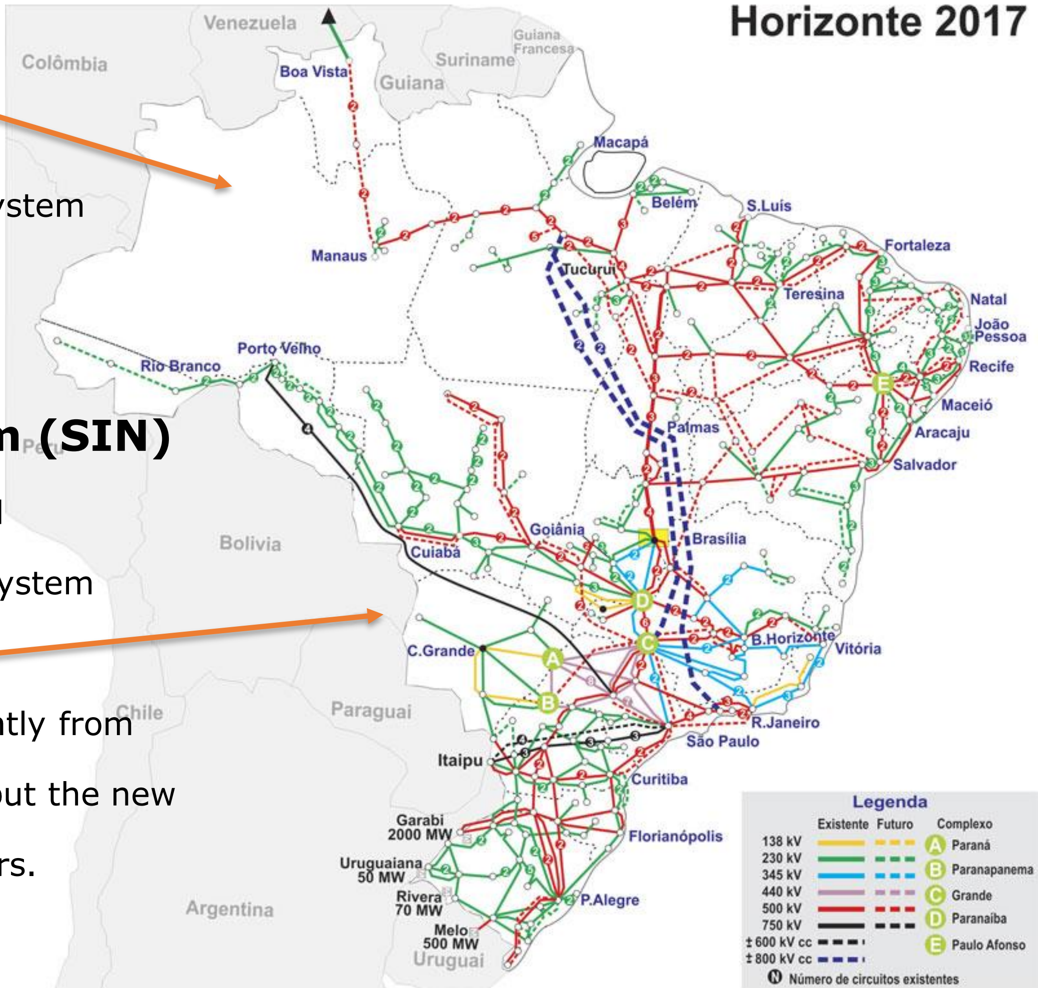
- Multiple ownership: 57 private and public utilities own 152 hydro plants (> 30 MW) in 16 river basins→ 105.158 MW (Dec'17).
- There are currently 69 plants with reservoir (monthly regulation or above), 85 run-of-river plants and 4 pumping storage plants.
- Interdependence among plants and river basins in power production is the basis for the **centralized coordinated** operation of BIPS.

Global map of the grid and of its interconnections

Long distance AC and DC links, international and inter-regional transmission links, seasonal and intermittent energy offer.



Global map of the grid and of its interconnections



- **Isolated System**
  - ✓ In the Amazonia Region
  - ✓ Represents 1.7 % of the Brazilian Power System
  - ✓ Predominance of Thermal Power Plants

- **National Interconnect System (SIN)**
  - ✓ 136,000 km of Transmission Lines Installed
  - ✓ Represents 98,3% of the Brazilian Power System
  - ✓ Predominance of Hydro Power Plants
  - ✓ Brazil has its electricity coming predominantly from hydroelectric generation with large reservoirs, but the new hydroelectric plants tend to have small reservoirs.

Grid facts and characteristics

❑Strategic importance of transmission:

- Multi-owned T system: 121 agents have about 135,000 km of lines at 230 kV and above.
- Expansion of transmission grid by auctions
- Transmission grid not only links generation plants to load centers, but also allows optimization in the use of available energy resources and improvement in safety of supply

Structure of electrical power system

- The Brazilian Interconnected Power System covers most of the national territory.
- The BIPS supplies more than 99% of the total load of the country (574.3 TWh in 2017).
  Peak Demand was 85.3 GW in Feb'14.
- Hydro generation is dominant: about 68.3% of the total installed capacity in 2017.
- Thermal generation is produced with diversity of fuels: nuclear, coal, natural gas, oil, diesel, biomass. Total was about 23.6% in 2017.
- Small share of non-conventional renewable energies: wind and solar (about 8.1% in 2017) .

Structure of electrical power system

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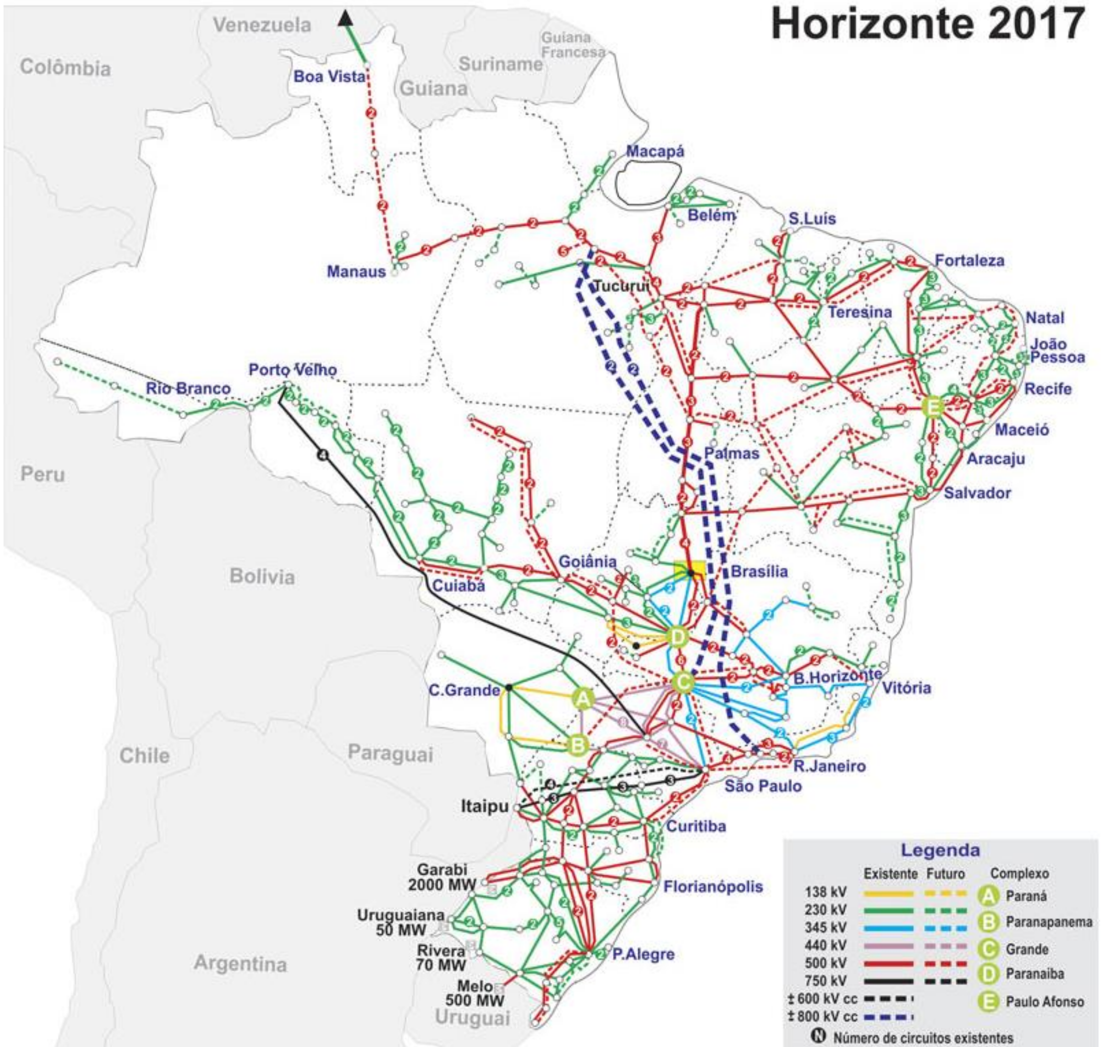
  85 run-of-river plants and 4 pumping storage plants.
- Interdependence among plants and river basins in power production is the basis for the **centralized coordinated** operation of BIPS.

Map of the high voltage grid



Information on ISO(s)

- Name: Operador Nacional do Sistema -ONS
- Network length (km) = 137.846
- Served area (km^2) - 8.516.000 km^2
- Annual transmitted energy (TWh) –
- website: http://www.ons.org.br/

Cooperation of ISO and TSO/DSOs

ONS's field of action

Generating System

~ 260 plants ≥ 30 MW

> 1.200 generating units

128 Agents

Generation

Transmission Basic Grid

About 135.000 km of TLs of 230kV and above

121 Agents

Transmission

Distribution + Free Consumers

574.3 TWh
Energy Load in 2017

85,283 MWh/h
Hourly Peak Demand in 2017
20/02/2017 at 14:00h

83 Agents

Consumption

- Hydrothermal dispatch and operation of system reservoirs by ONS
- Operation of transmission grid by ONS
- Operation of installations by G and T utilities

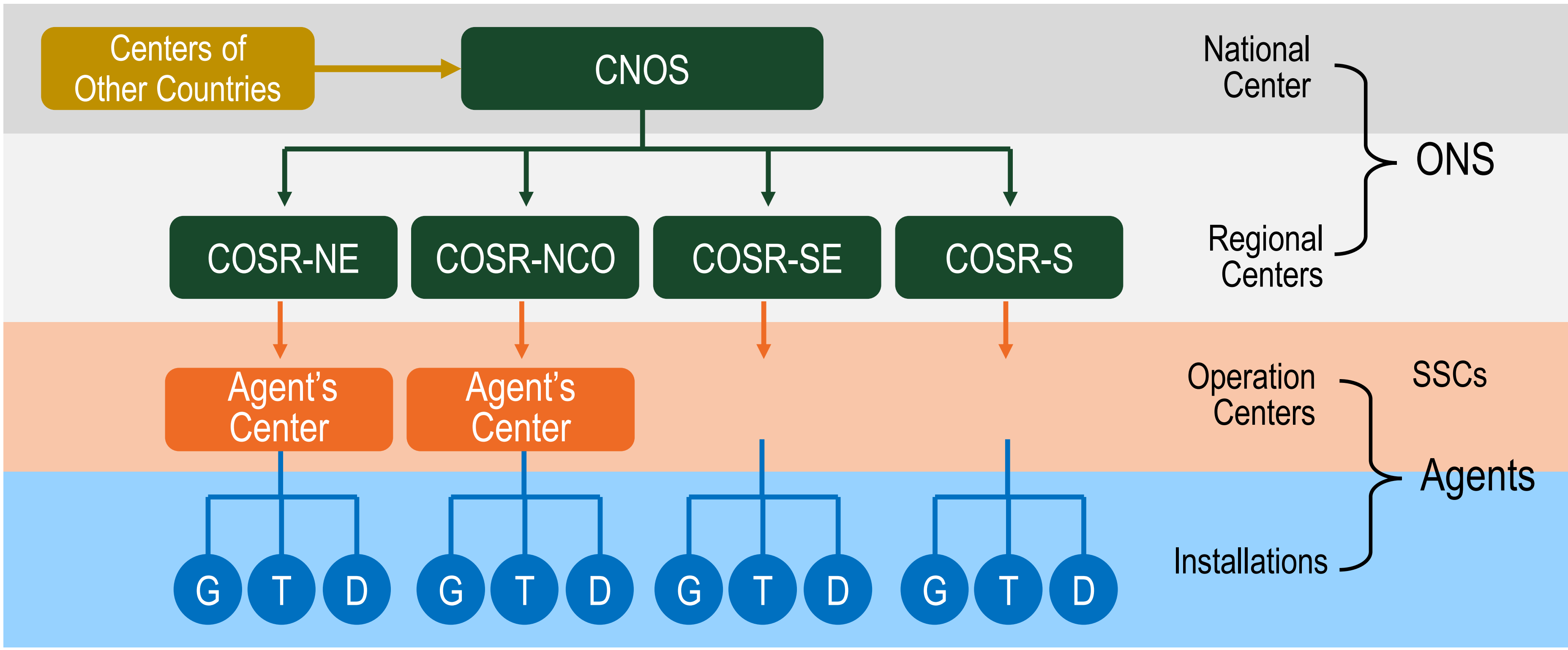
More than 1,000 connection points between Basic and Distribution Grids

- Operation by Discos
- Retail supply

(*) Total number is 331. Some agentes are vertically integrated utilities

Cooperation of ISO and TSO/DSOs

Technical Hierarchy

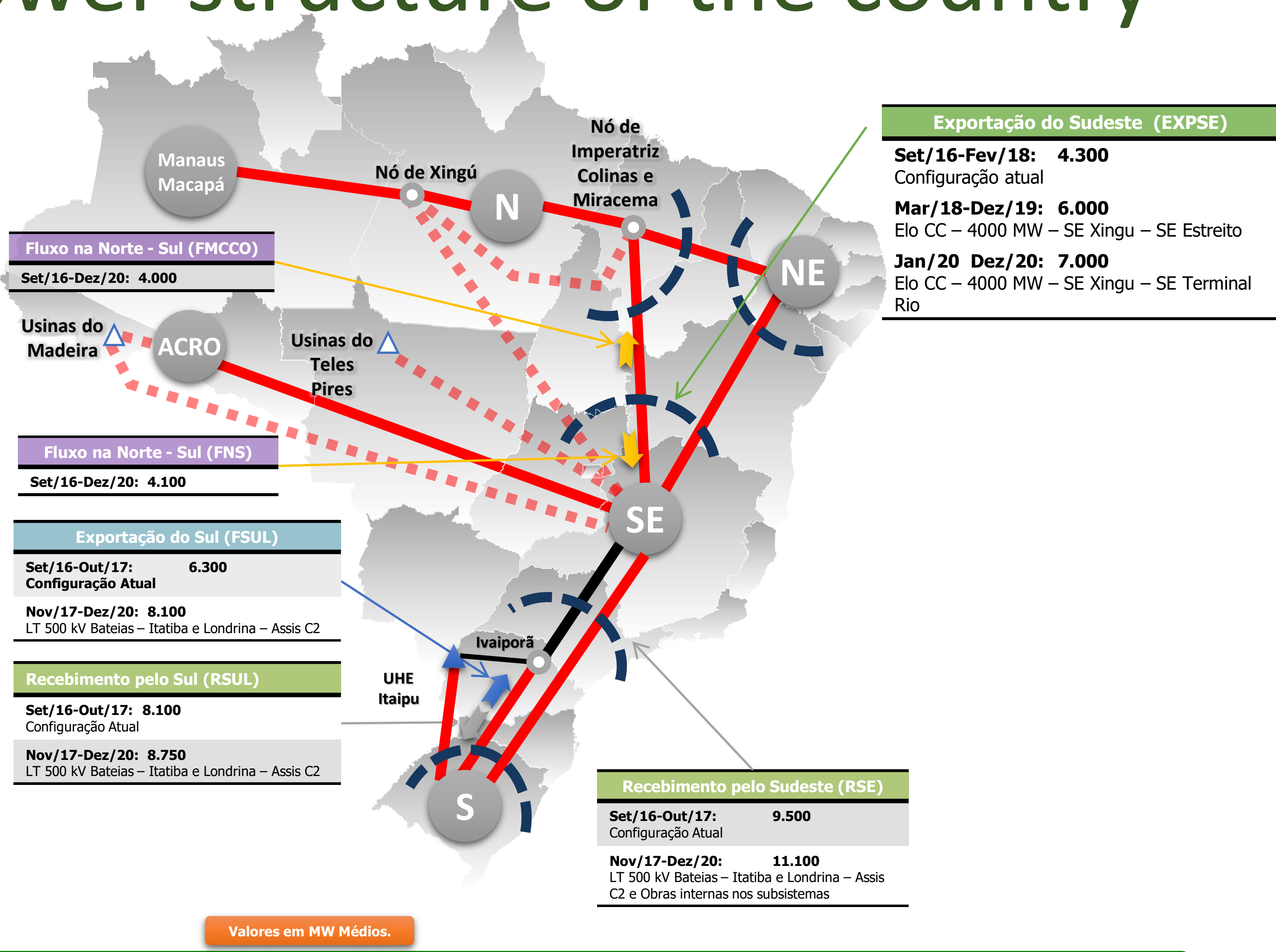


Responsibilities of TSO & DSOs

The **ONS** is the institution responsible for operating , monitoring and controlling the generation of electricity in the National Integrated System -SIN and for managing the main grid of electricity transmission in Brazil.

The **ONS** has as main objectives the fulfillment of the load requirements , cost optimization and system reliability assurance. Another responsibility is to define the conditions of access the high voltage transmission grid in the country.

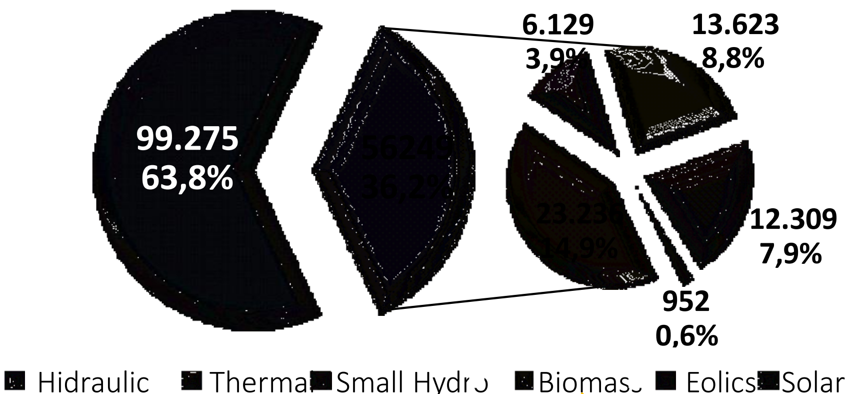
Power structure of the country



Installed capacity with reference to primary resources

Total Availablel: 155.524 MW

Installed capacity installed in 12/31st/2017

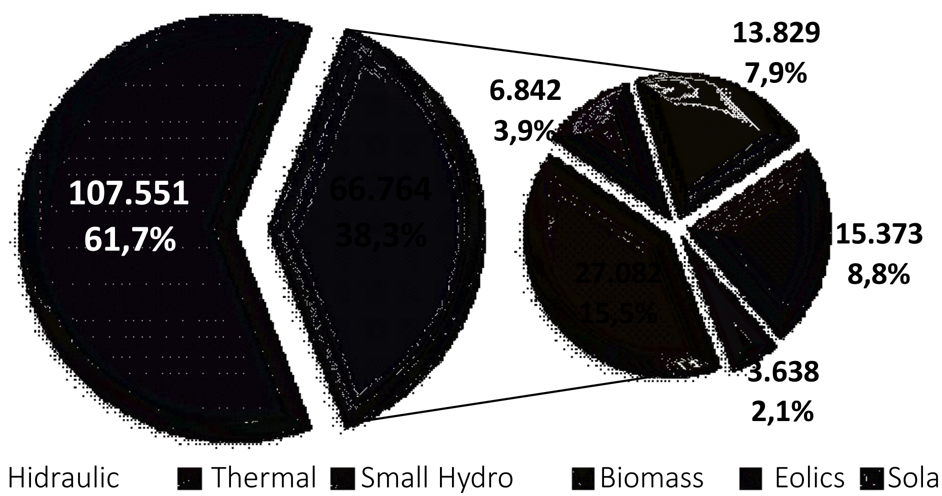


* Included Itaipu 60Hz and Buys Itaipu 50Hz

Total Available : 155,524MW

Capacity preview for 12/31st/2022

Total Available: 174,315 MW



* Included Itaipu 60Hz and Buys Itaipu 50Hz

Installed capacity

Source	Capacity 2017 (GW)	%
Wind	12,590	7,7%
Hydro	109,467	66,6%
Small Hydro Power Plants (SHPP)	5,048	3,1%
PV solar	0,952	0,6%
Biomass	12,608	7,7%
Coal	3,154	1,9%
Gas	12,423	7,6%
Oil	4,787	2,9%
Double Fuel - Gas/Oil	0,772	0,5%
Nuclear	2,007	1,2%
Thermal - Others	0,545	0,3%
Total	**164,353**	**100,0%**

Energy Production – TWh

Source	Generation 2017 (TWh)	%
Wind	41,4	7,6%
Hydro	364,8	66,8%
Small Hydro Power Plants (SHPP)	20,7	3,8%
PV solar	0,6	0,1%
Biomass	25,6	4,7%
Coal	13,2	2,4%
Gas	51,0	9,3%
Oil	7,4	1,4%
Double Fuel - Gas/Oil	3,3	0,6%
Nuclear	14,5	2,6%
Thermal - Others	4,0	0,7%
Total	**546,3**	**100,0%**

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Generation x Consumption Losses – TWh

2017	TWh
Generation (G)	557,26
Consumption (C)	535,37
Losses	21,88
G /C in the Gravity Center (50% Losses for G and 50% Losses for C)	546,327
Loss Factor G (%)	2,0%
Loss Factor C (%)	2,0%

CCEE

Number of Power Plants

Source	Number of Power Plant	%
Wind	494	28,5%
Hydro	194	11,2%
Small Hydro Power Plants (SHPP)	615	35,5%
PV solar	40	2,3%
Biomass	266	15,4%
Coal	11	0,6%
Gas	48	2,8%
Oil	50	2,9%
Double Fuel - Gas/Oil	5	0,3%
Nuclear	2	0,1%
Thermal - Others	7	0,4%
Total	**1.732**	**100,0%**

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Capacity Installed Projection (MW) 2016-2026

Source	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Hydro	89.698	94.846	99.846	102.008	102.008	102.008	102.150	102.268	102.501	102.937	103.466
SHPP	5.820	6.052	6.270	6.393	6.658	6.658	6.958	7.258	7.558	7.858	8.158
Wind	10.025	12.843	15.598	16.645	17.645	19.450	21.254	23.058	24.862	26.666	28.470
Biomass	12.881	13.010	13.182	13.506	13.577	14.199	14.666	15.234	15.802	16.368	16.936
PV Solar	21	960	1.990	2.660	3.660	4.660	5.660	6.660	7.660	8.660	9.660
Nuclear	1.990	1.990	1.990	1.990	1.990	1.990	1.990	1.990	1.990	1.990	3.395
Natural Gas	12.532	13.123	13.151	13.151	14.672	14.672	14.672	16.172	16.172	16.756	17.339
Coal	3.174	3.174	3.174	3.514	3.514	3.514	3.514	3.514	3.514	3.514	3.514
Oil	3.721	3.721	3.721	3.721	3.721	3.721	3.721	3.721	3.287	1.805	1.774
Diesel	1.530	1.530	1.530	1.530	1.530	1.530	1.530	1.337	787	787	612
Import	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000
Max. Demand						994	2.532	4.334	8.002	12.198	12.198
Total	**148.392**	**158.249**	**167.452**	**172.118**	**175.974**	**180.395**	**185.646**	**192.546**	**199.136**	**206.539**	**212.522**

EPE

Energy production with reference to primary ressources

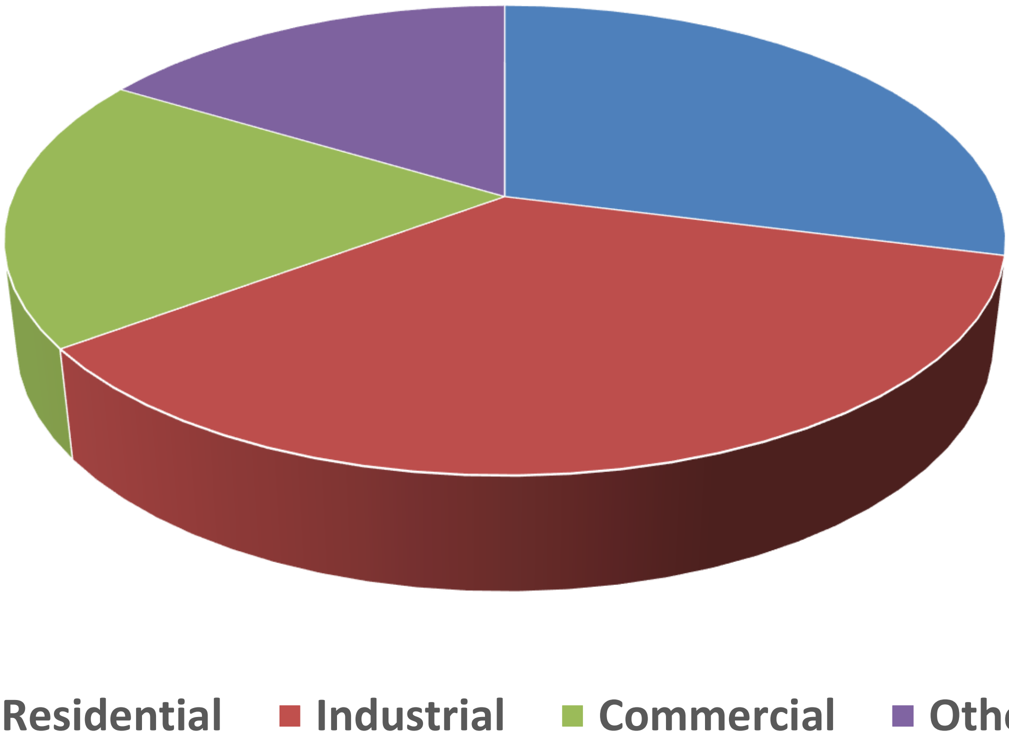
- Electricity generated (590,5 TWh), year 2014
  - Biomass 7,2%
  - Coal 3,1%
  - Gas 13,0%
  - Hydro power 65,2%
  - Lignite -
  - Nuclear 2,5%
  - Oil 6,9%
  - Solar power 0,4%
  - Wind power 2,0%
  - Others –

Development of generation capacity since ….

Type	2017		2022		Growth 2017-2022	
	MW	%	MW	%	MW	%
Hydro	105,158	68.3	114,295	66.3	9,137	8.69
Nuclear	1,990	1.2	1,990	1.2	-	-
Gas / LNG	12,597	8.2	15,847	9.2	3,250	25.8
Coal	3,138	2.0	3,483	2.0	345	11
Oil / Diesel	4,732	3.1	4,732	2.7	-	-
Biomass	13,193	8.6	13,300	7.7	107	0.8
Other(1)	809	0.5	980	0.6	171	21.1
Wind	12,020	7.8	15,043	8.7	3,023	25.1
Solar	415	0.3	2,708	1.6	2,253	652.5
Total	**154,052**	**100**	**172,378**	**100**	**18,326**	**11.9**

Source: PEN 2018 – ***preliminary data***

Comsuption per customer groups

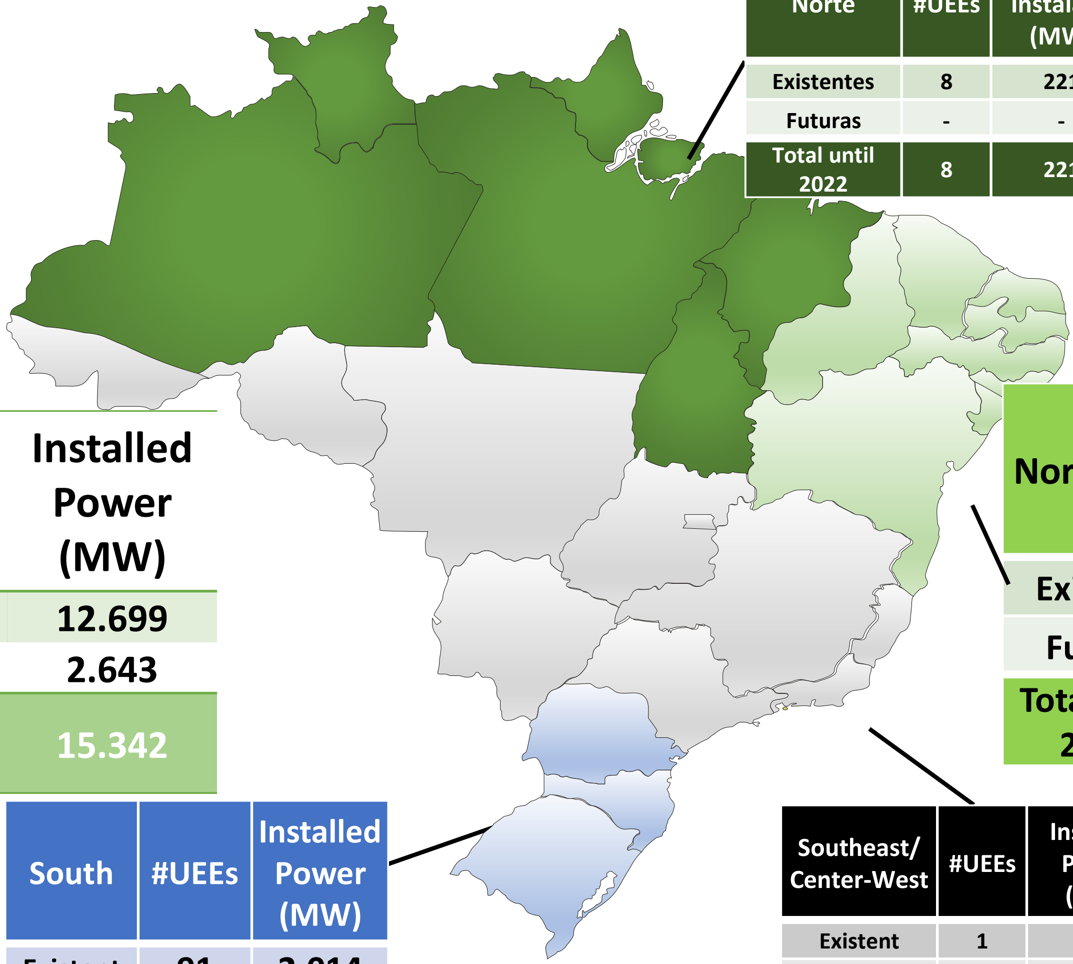


TWh/year
% of total

Values at comsuption points

Others: Rural, Sanitation, Public Service, Street Lighting, ….

Location of renewable (Wind)



Norte	#UEEs	Potência Instalada (MW)
Existentes	8	221
Futuras	-	-
Total until 2022	8	221

Northeast	#UEEs	Installed Power (MW)
Existent	411	10.436
Future	115	2.613
Total until 2022	526	13.049

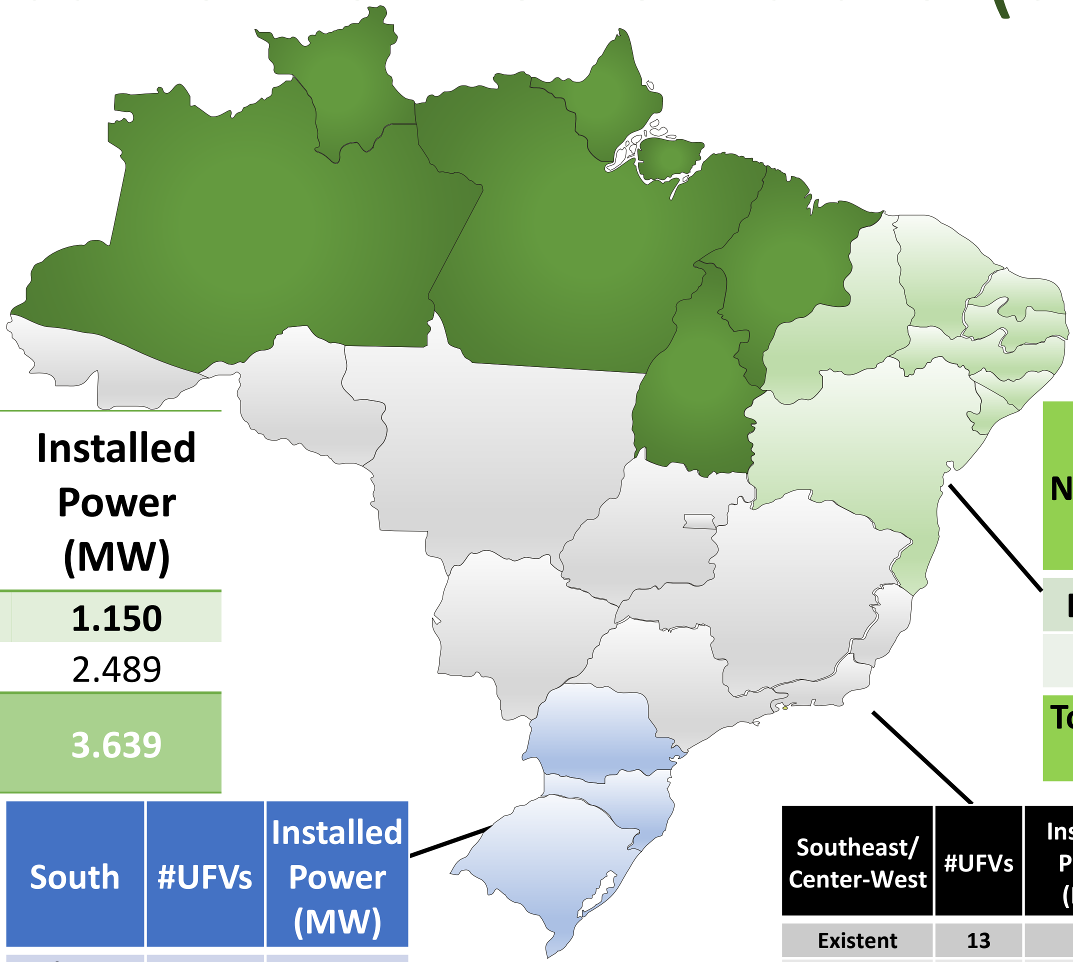
SIN	#UEEs	Installed Power (MW)
Existent	503	12.699
Future	117	2.643
Total until 2022	620	15.342

South	#UEEs	Installed Power (MW)
Existent	91	2.014
Future	2	29
Total until 2022	93	2.044

Southeast/ Center-West	#UEEs	Installed Power (MW)
Existent	1	28
Future	-	-
Total until 2022	1	28

85% of Projects

Location of renewable (solar)



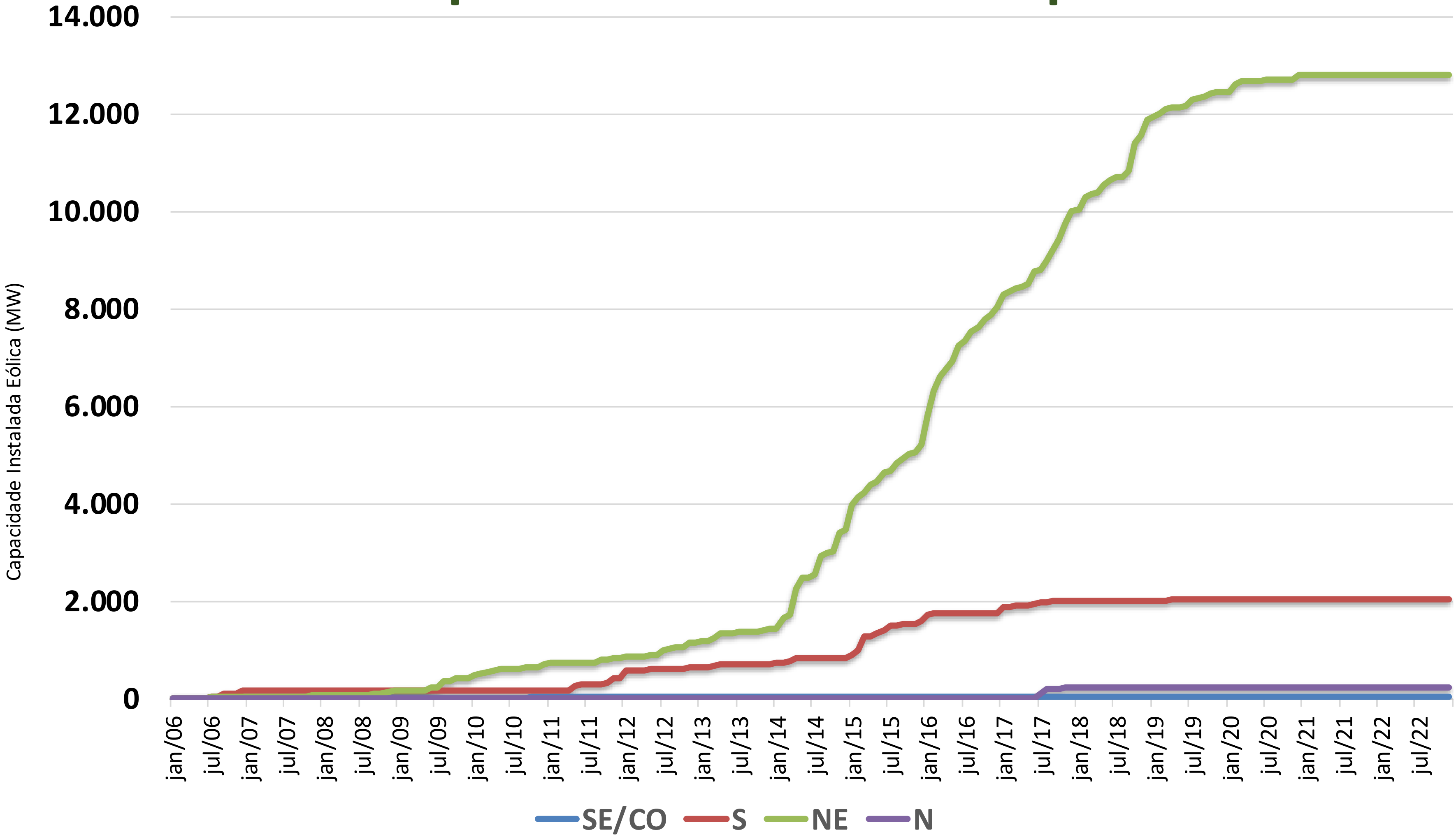
SIN	#UFVs	Installed Power (MW)
Existent	47	1.150
Future	89	2.489
Total until 2022	136	3.639

Northeast	#UFVs	Installed Power (MW)
Existent	32	822
Future	62	1.742
Total until 2022	94	2.564

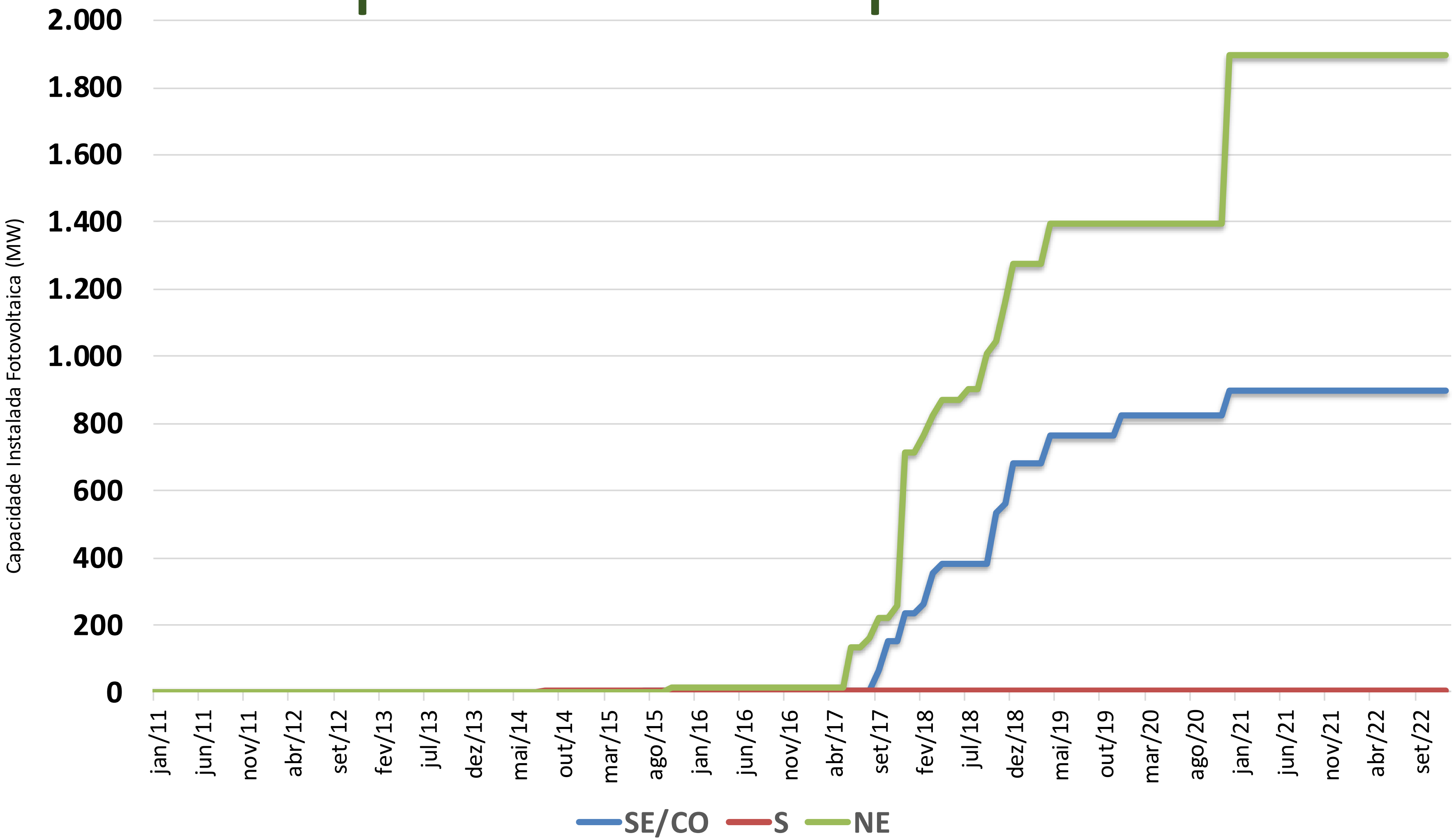
South	#UFVs	Installed Power (MW)
Existent	2	4
Future	-	-
Total until 2022	2	4

Southeast/ Center-West	#UFVs	Installed Power (MW)
Existent	13	324
Future	27	747
Total until 2022	40	1.070

Development of wind power



Development of photovoltaic power



RES installed capacity and production since …

Capacity History by source - GW	01/12/2015	01/12/2016	01/12/2017
Wind	8,277	10,221	12,590
Hydro	95,488	107,335	109,467
Small Hydro Power Plants (SHPP)	5,114	5,369	5,048
Thermal - Others	1,181	0,545	0,545
Biomass	10,999	12,499	12,608
Coal	3,190	3,154	3,154
Gas	11,705	11,849	12,423
Oil	5,025	4,587	4,787
Double Fuel - Gas/Oil	0,979	0,979	0,772
Nuclear	2,007	2,007	2,007
PV solar	0,021	0,019	0,952
Total	**143,985**	**158,563**	**164,353**

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Price development for industry consumers

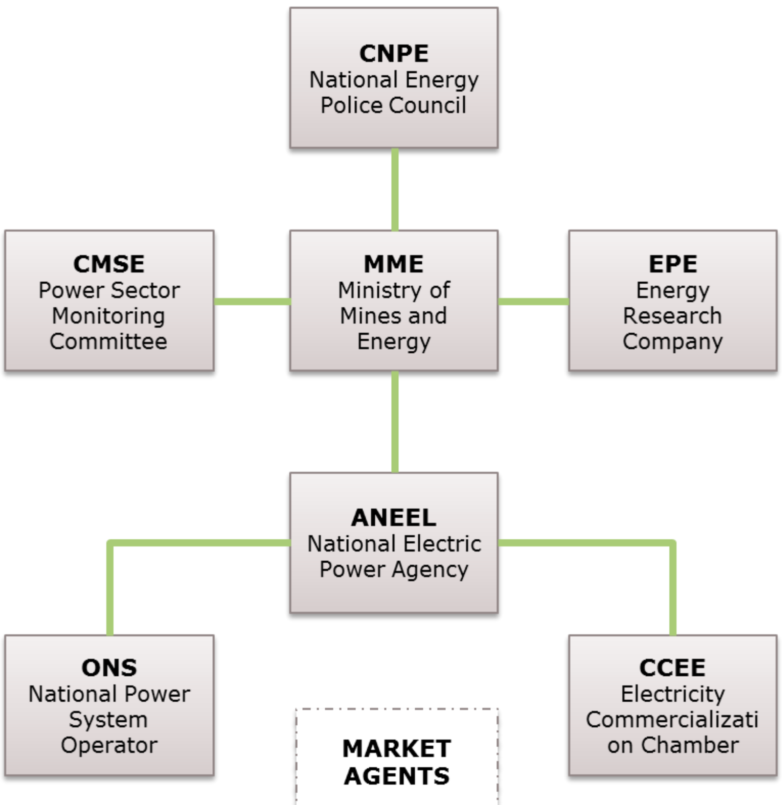
- The electricity tariffs are defined by regulator (ANEEL) for captive users and separated in four blocks: energy-only, transportation, sector charges and taxes
- Industry consumers are almost all in free market and energy-only prices are negotiated directly with suppliers and other blocks are defined by ANEEL
  - Some of them (usually smallers) can buy from renewables and also receive some benefits on transportation
  - Self-producers can also have benefits on sector charges

Price development for households

- Household users are captive and are fully supply by local distribution utilities
- The electricity tariffs of each distribution utility are defined by regulator (ANEEL) for household captive users and separated in four blocks: energy-only, transportation, sector charges and taxes
- There are regulatory rules for energy-only prices pass-through to captive final users

Electricity Market Organisation

Electric Sector Governance



- **CNPE:** Responsible for the definition of the energy policies with the objective of ensuring the supply
- **MME:** Responsible for the planning, management and development of the sector legislation; supervises and controls energy policies execution
- **EPE:** Responsible for the planning of generation and transmission expansion; linked to MME, supports technically the energy auctions
- **CMSE:** Monitors the system to ensure the reliability and guarantee of supply
- **ANEEL:** Regulates and Monitoring the generation, transmission, distribution and commercialization of electricity. Sets the tariffs and ensures the financial and economic balance of the concessions
- **ONS:** Controls the operations of the National Integrated System to ensure the optimization of the energy resources
- **CCEE:** Manages the electricity market transactions and the regulated auctions
- **MARKET AGENTS**: Generators, Distributors, Traders and Free Consumers

Electricity Market Organisation

SELLERS
Generation of public services, independent energy producers, traders and self producers

~ 70% of consumption

Regulated Contracting Environment (ACR)
Distributors *(captive consumers)*

Contracts result from auctions

All seller perform contract with all Distribution companies

Free Contracting Environment (ACL)
Free consumers, traders (reselling)

~ 30% of consumption

Contracts freely negotiated

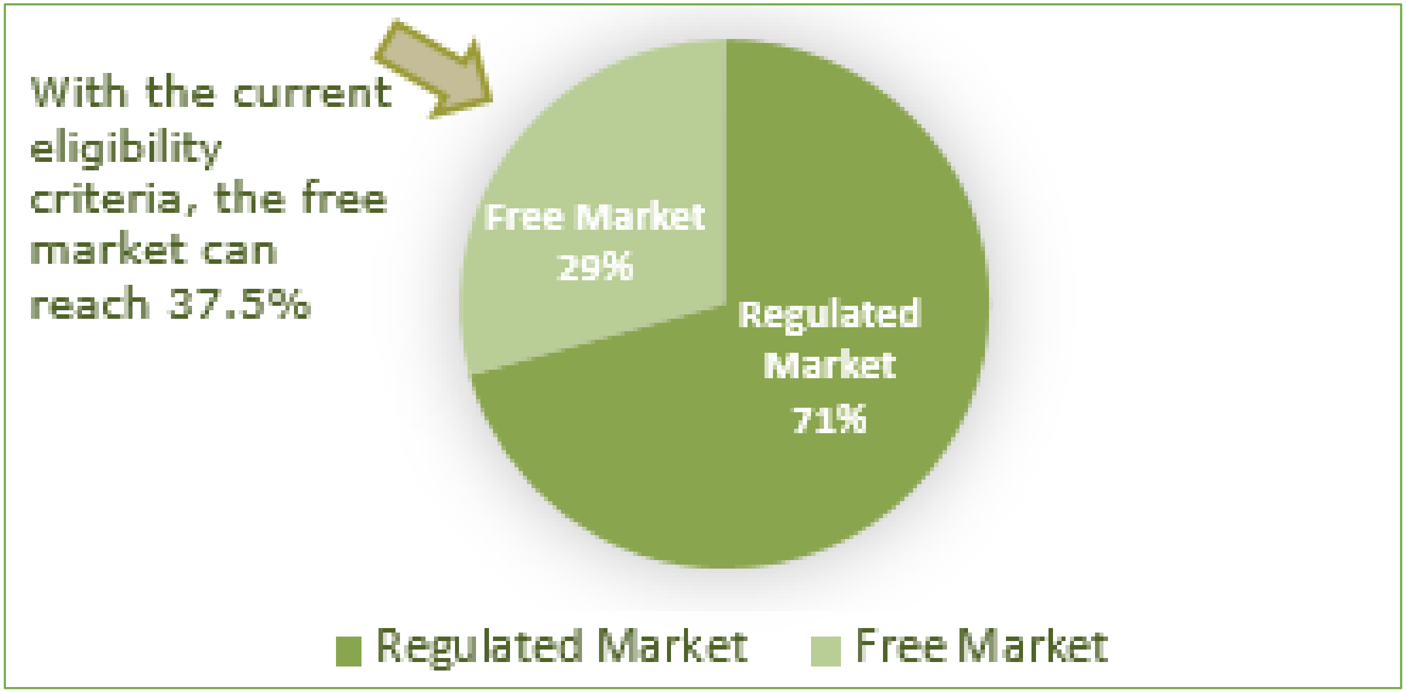
Electricity Market Organisation

Free Market Eligibility

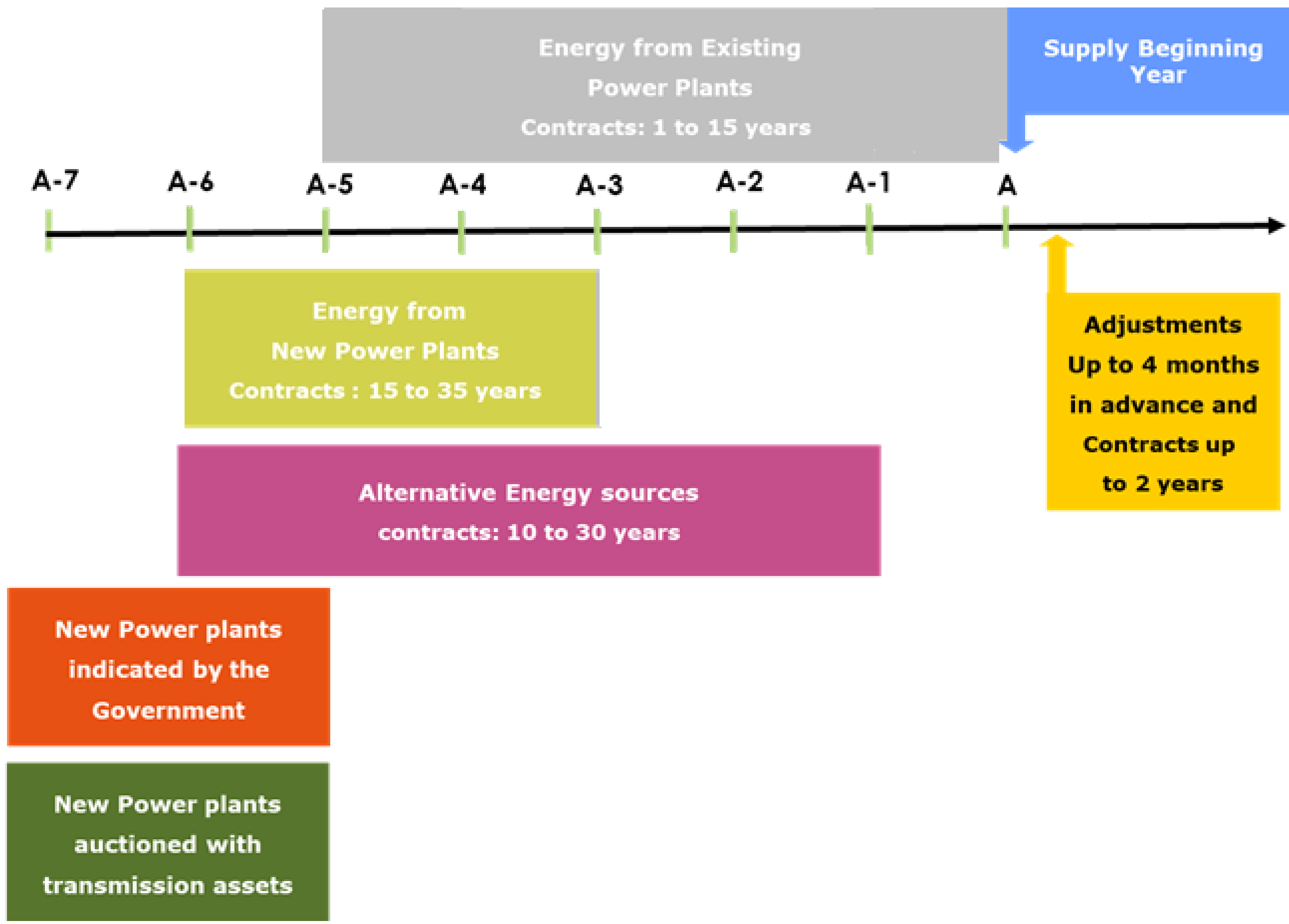
CONSUMER	MINIMUN DEMAND	MINIMUN VOLTAGE
Free	3 MW	Consumer connected to a voltage equal or higher than 69 KV before July 8th of 1995
		No minimum voltage is required after July 8th of 1995
Special	500 KW	-

Units or a set of consumer units that can migrate to the free market and choose their supplier, as long as they buy energy from **incentivized** generation sources: Small Hydro Power plants, Biomass, Wind and Solar.

Electricity Market Organisation



Regulated Market Contracting



Free Market Contracting

Montantes de contratos em 2017 CCEAL de compra de consumidores livres e especiais centro de gravidade por tempo remanescente

ACL Contracts by duration	Average MW	%
1 month	550,635	3,4%
2-5 months	1.351,557	8,5%
6 months to 1 year	2.366,234	14,8%
1 – 2 years	2.617,343	16,4%
2 – 4 years	5.517,795	34,5%
4 – 6 years	1.378,629	8,6%
6 – 8 years	1.083,562	6,8%
8 – 10 years	117,865	0,7%
10 – 12 years	165,425	1,0%
Higher than 12 years	840,448	5,3%
Total	**15.989,493**	**100,0%**

*Average MW = MWh/Number of hours (month)

CCEE

Power balance in 2017

- Generation (TWh) 557,26
- Consumption (TWh) 535,37
- Imports (TWh) 1,3
- Exports (TWh) 0
- Losses (TWh) 21,88

Energy exchanges in ….

- Commercial flows
- Physical flows

- The average relation of commercial and physical flows is around 2.5 times in the Brazilian wholesale market

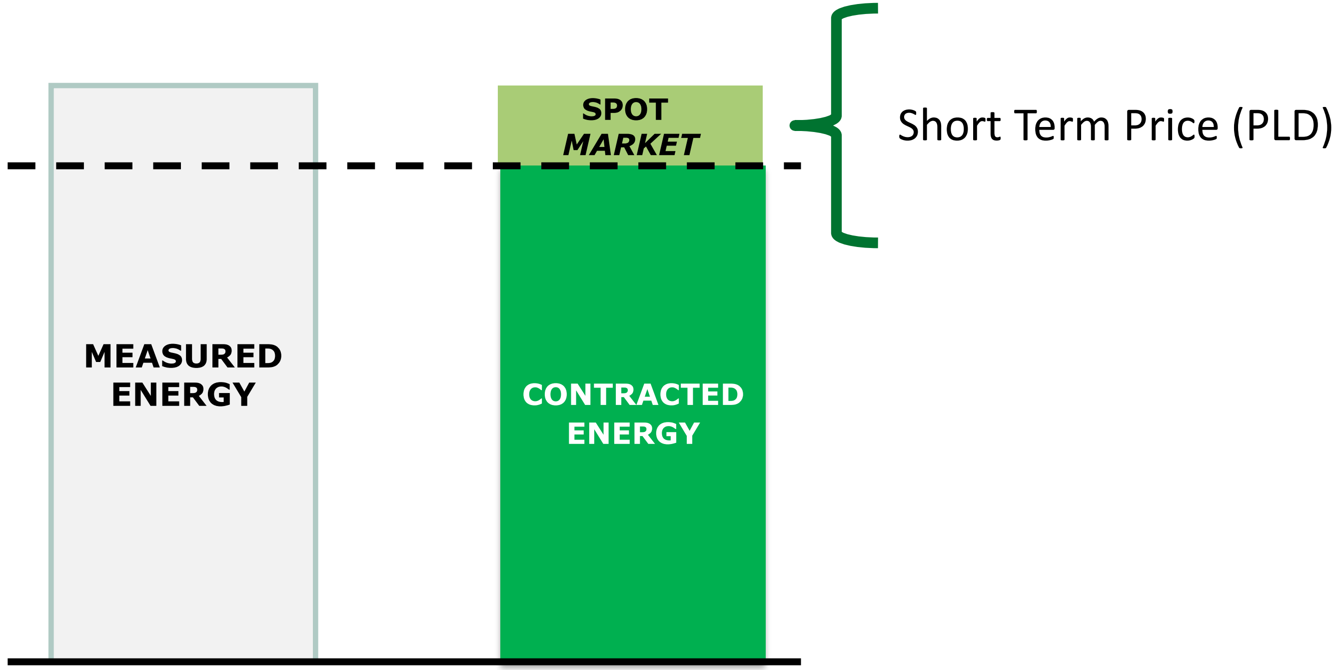
Specific aspects of the electricity market

- ❑ Market coupling
- ❑ Market splitting
- ❑ Day-ahead
- ❑ Futures

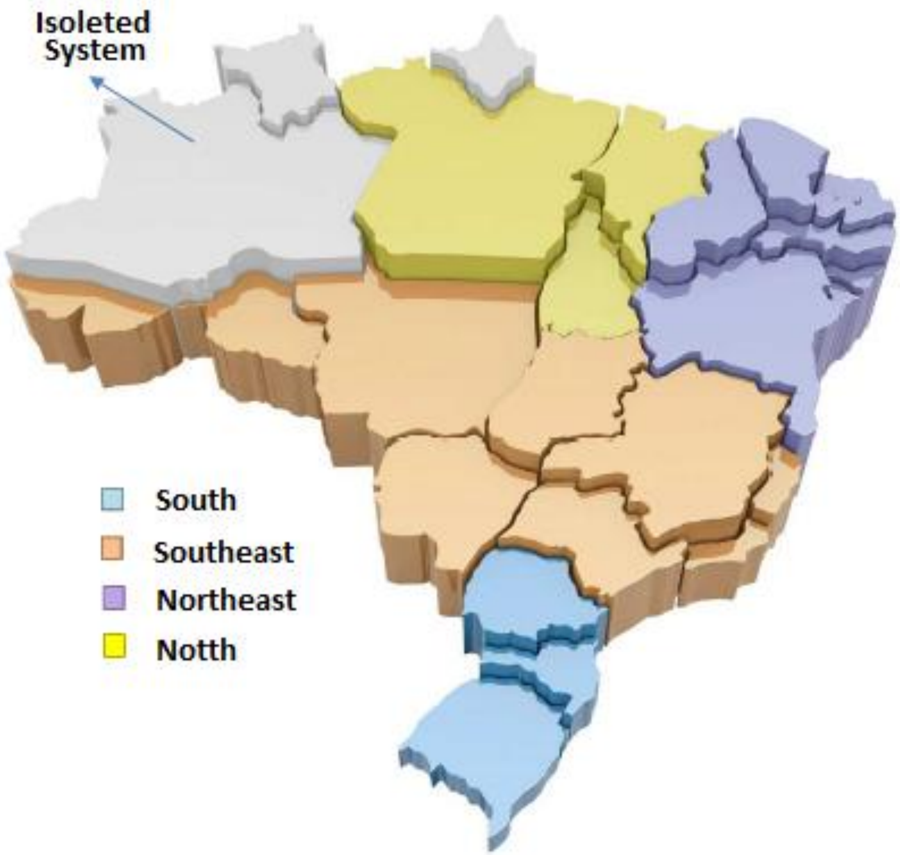
Note that there is no market coupling/splitting in Brazil.

We have only opportunity exchange between countries (in firm energy) and at Brazil - Paraguay Bi-national Plant (Itaipu - 14 GW)

Short Term Market



Short Term Market



- The System Operator is responsible for the centralized dispatch of the most of power plants in the system.

- There are 4 regions (submarkets) for which the spot price (PLD) are weekly calculated by the Market Operator using computational models.

- Agents can buy energy from any other agents connected to the SIN, no matter the submarket, however these agents can be exposed to differences in the spot prices between the submarkets.