Overview of the Brazilian Power Market

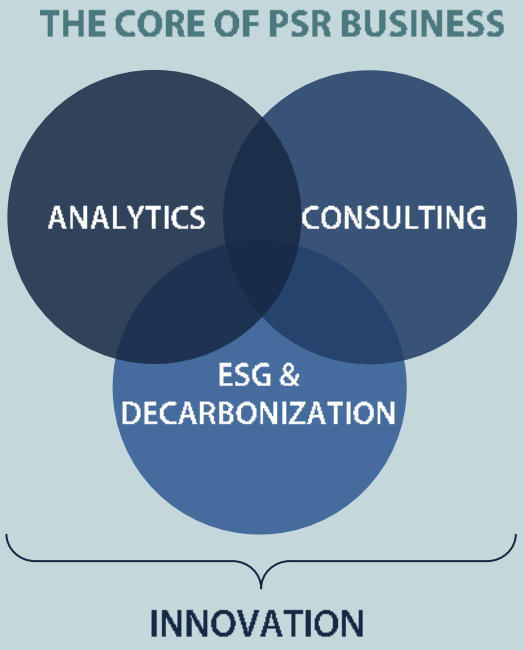
Electricity Market Training Program (EMTP)

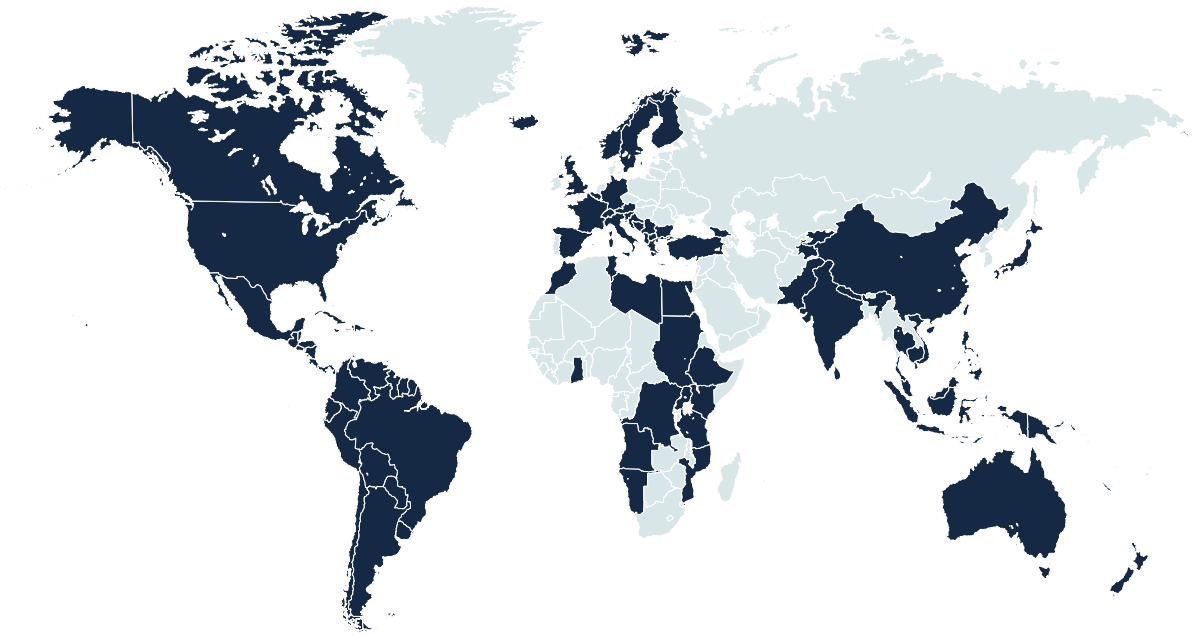
Pakistan, 2024

Ricardo Perez

ricardo@psr-inc.com

OUR EXPERIENCE AND PRESENCE





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OUR SOLUTIONS

NCP

Short-term Dispatch Tool

- Short-term planning model
- Determines the least cost dispatch of power systems in hourly or sub-hourly time steps
- Co-optimization of dispatch and reserves
- Common applications: day-ahead, week-ahead and re-dispatch planning
- Inertia and frequency control ancillary services
- Integration with mid/long-term models

SDDP

Operation Planning Tool

- Mid- and long-term operational studies
- Stochastic model with advanced representation of uncertainties and storage
- Detailed representation of transmission and fuel networks
- Co-optimization of energy and reserve markets
- From one single system up to regional markets with integrated sub-systems in multiple countries
- Monthly, weekly and up to hourly resolution

OptGen

Capacity Expansion Planning

- Long-term planning model
- Trade-off between investment costs and expected value of operating costs
- Integrated generation and transmission expansion planning
- Use of SDDP's features to represent electrical systems and to determine the optimal operational dispatch with alternative expansion plans
- Energy policy constraints

Included tools :

Time Series Lab
Renewable modeling tool

OptMain
Maintenance schedule optimization

Coral
Reliability tool

PSR Cloud
High-performance computing environment

PSRIO
Business intelligence tool for advanced data analysis

API
Application Programming Interface

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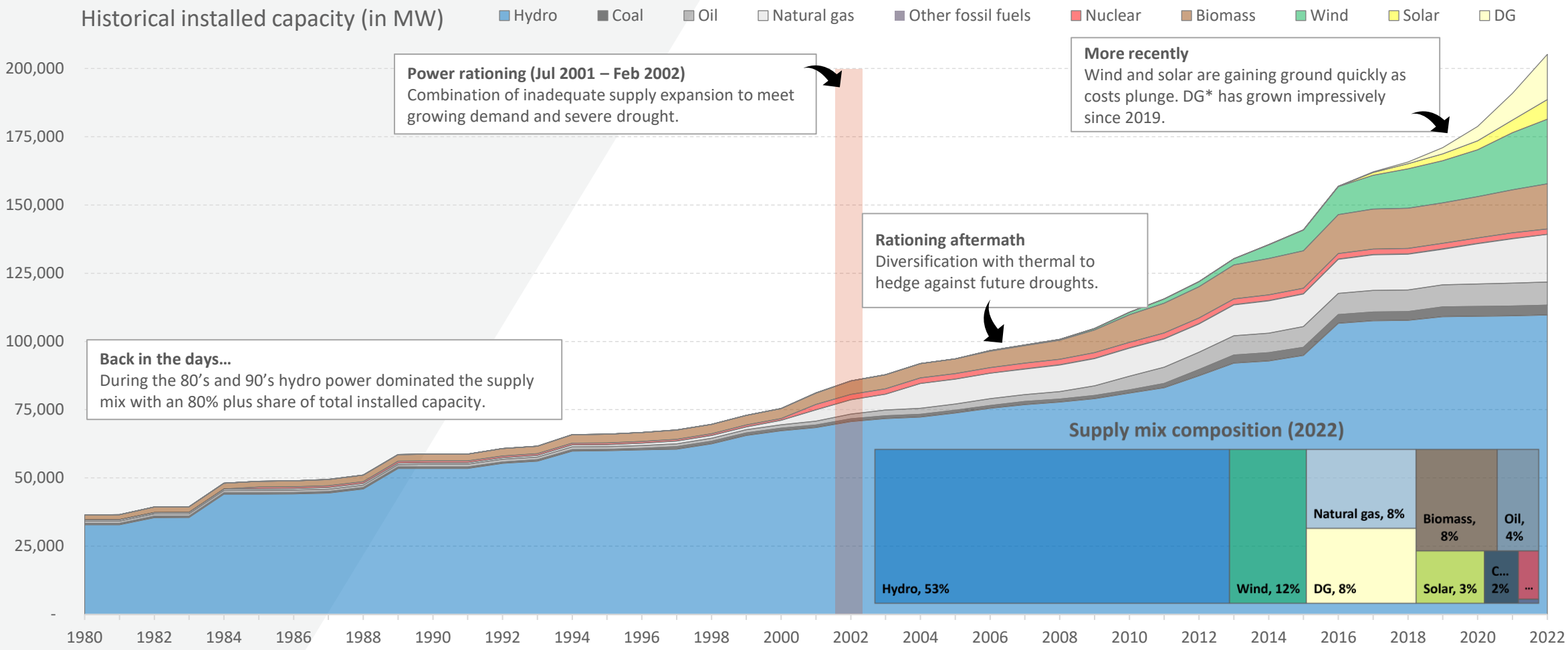
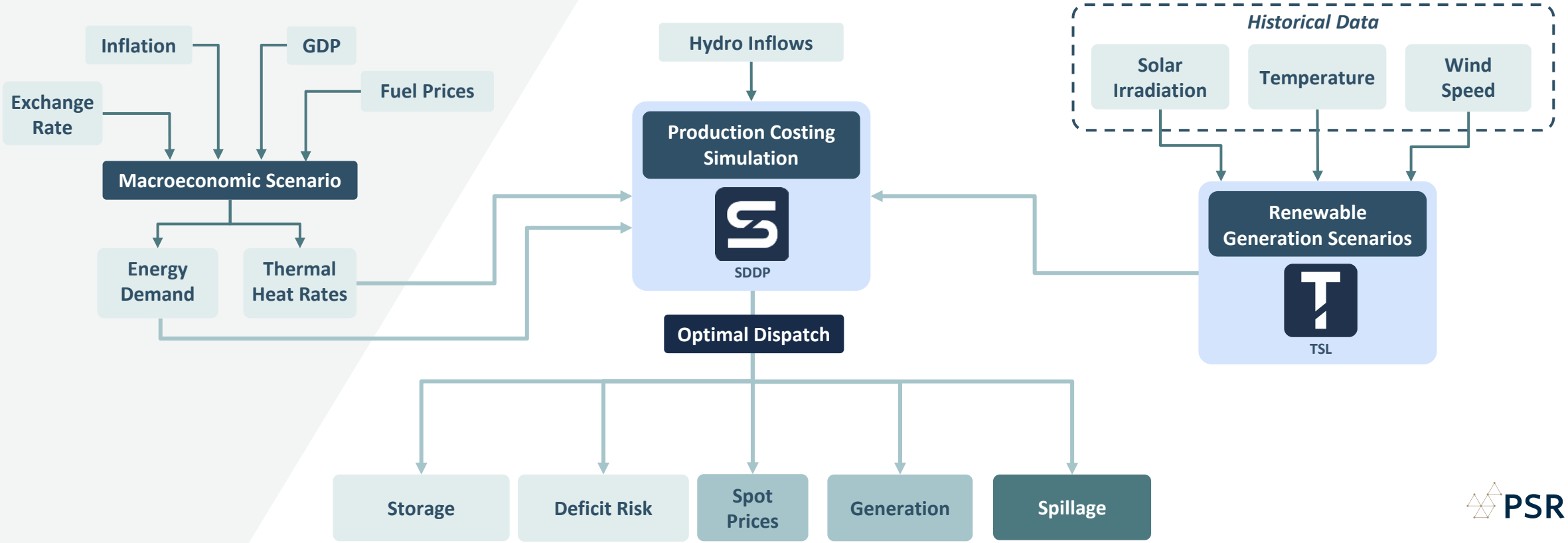
Brazil's electricity supply mix is mostly renewable



(*) Distributed generation (DG) is 99% solar

Price Formation

- Power plants are centrally dispatched by the ISO using a suite of computational models whose objective is to minimize the expected value of the system's total operating costs
- Spot prices are a by-product of the dispatch algorithms ➔ the load marginal costs (LMCs)
- After the LMCs are calculated, a (regulatory) cap and floor is applied to them



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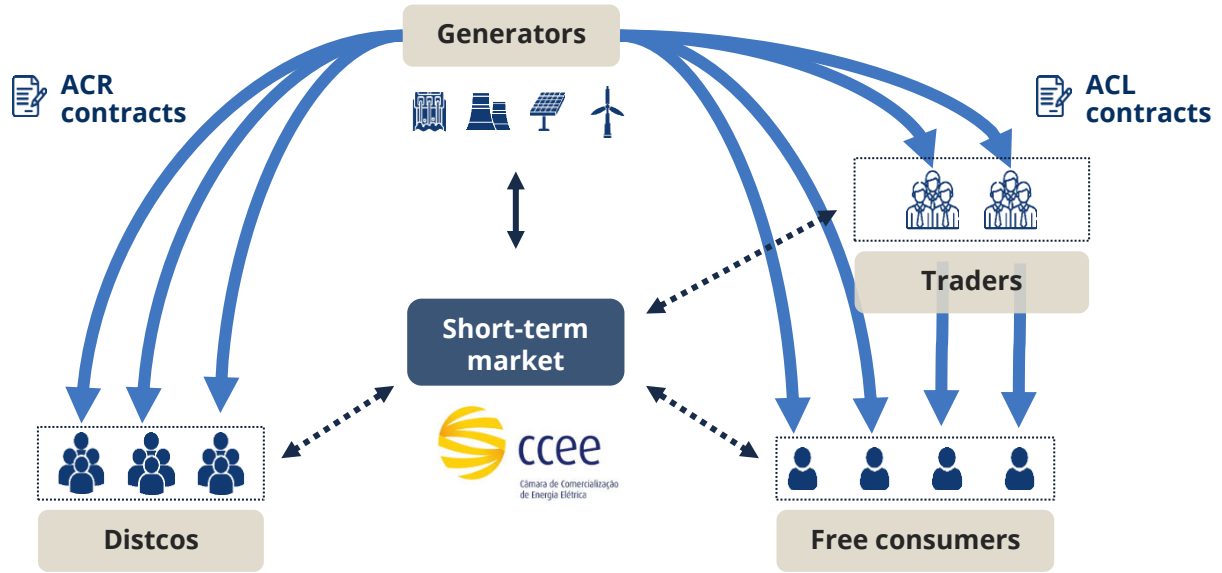
Brazilian Power Market Structure

- The Brazilian power market is structured around in two major markets:

- **PPA market:**
  - **Regulated Market (ACR):** used exclusively by distribution companies (DISCOs) to supply their customers (known as regulated or captive consumers). PPAs are standardized and offered in auctions organized by the government.
  - **Free Market (ACL):** market in which end-consumers are free to negotiate their own PPAs with generators or traders, with terms and prices negotiated bilaterally

- **Spot market:** market in which surpluses or shortfalls of energy, in regard to the contracted volumes, are cleared and settled (at the Spot Price). This market is managed and operated by the Electric Energy Trading Chamber (CCEE)



Generators settle (buy or sell) differences in production vs. PPA commitments on the short-term market at the spot price

Consumers and traders also settle differences between consumption and PPA commitments on the short-term market at the spot price

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System expansion via regulated auctions

Brief history

2005

First New Energy Auction was held in 2005

2005 to 2008
Expansion was mostly driven by hydro and thermal power plants.

2008

During this period, thermal expansion was dominated by **fuel/diesel oil**, followed by a few **coal** and **natural gas** projects

2009

Wind debut

There was the first exclusive wind power auction.
Currently, this source has over **25.76 GW** of installed capacity operating and **6 GW** under construction.

2014

The LNG business model appeared as an alternative to vertically integrated gas producers.

Solar debut

Solar still has little impact in the system's overall capacity, **9.43 GW**. However, there is around **5.75 GW** of solar capacity under construction.

2017

First winner using natural gas project from pre-salt oil fields (Marlim Azul project, from Shell/Patria/Mitsubishi)

2021

First Capacity Reserve Auction

Because of some conjunctural issues, the overall system flexibility has decreased. Thus, it became difficult to meet the peak demand and a capacity need in the system was created

2022

Law 14.182/2021, privatization of Eletrobras

+

Energy Capacity Reserve Auction

In July 2021 was approved the privatization of Eletrobras through the Law 14.182

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Energy auctions results – aggregates per source

Overall, power auctions have been very successful, effectively doubling the system's capacity since 2005

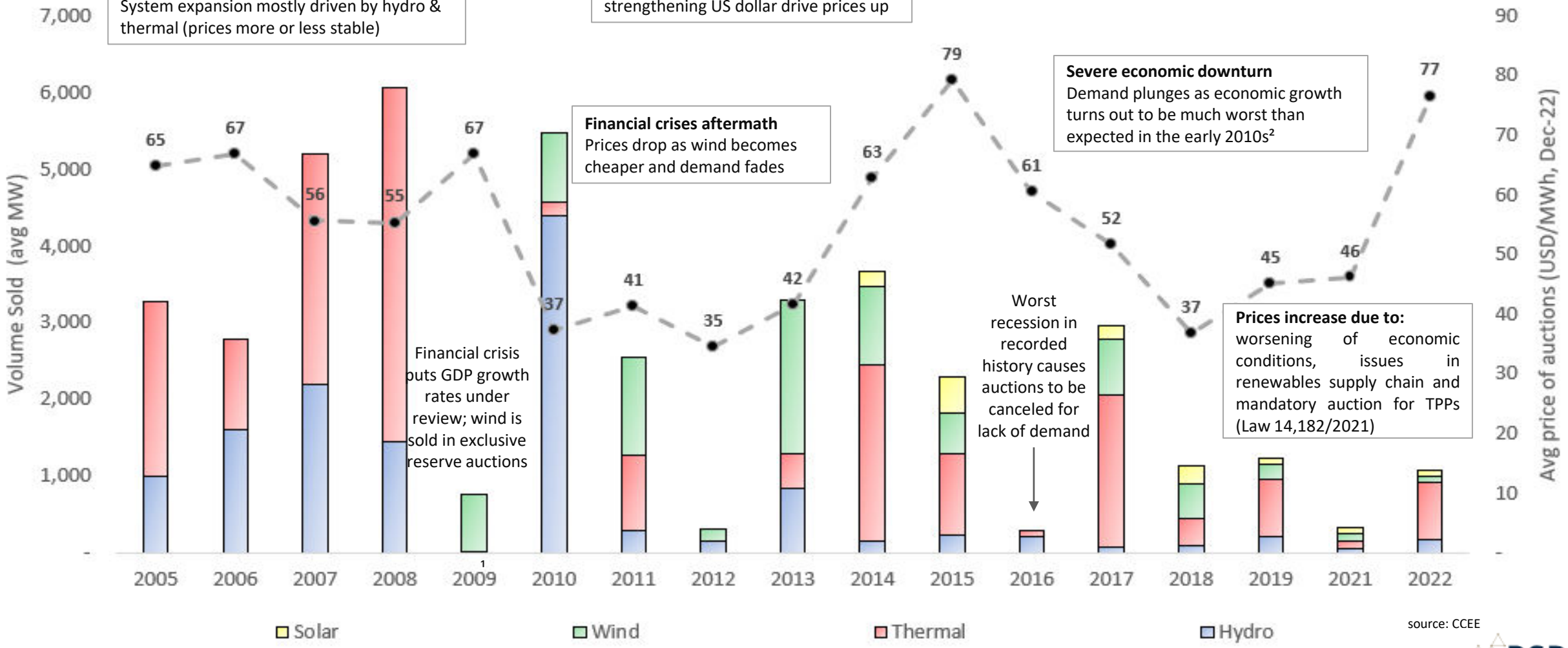
Early years
System expansion mostly driven by hydro & thermal (prices more or less stable)

Economic conditions worsen
Higher interest rates and a strengthening US dollar drive prices up

Financial crises aftermath
Prices drop as wind becomes cheaper and demand fades

Severe economic downturn
Demand plunges as economic growth turns out to be much worst than expected in the early 2010s[2]

Prices increase due to:
worsening of economic conditions, issues in renewables supply chain and mandatory auction for TPPs (Law 14,182/2021)



source: CCEE

[1] 3 of the 4.3 avg GW of hydro correspond to the Belo Monte project, which was auctioned in an exclusive tender.

[2] Because New Energy Auctions are held several years in advance of delivery, disappointing (unanticipated) demand growth can lead to oversupply (shortage) of energy.

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Key Takeaways (1/5)

What factors lead towards the adoption/origination of the electricity market in your country?

- As the expansion was based on large-scale structuring projects (predominantly hydro plants that have production uncertainty), with the aim of attracting investors and having revenue predictability, our expansion began based on auctions (since the reform of 2004) with long-term contracts

- Nowadays the market concentration is relatively mild – according to ANEEL, the top 10 players own 43% of the system´s installed capacity. Generation asset ownership is divided between federal, state-owned and private companies

- The companies in the Eletrobras system produce ~60% of the electrical energy consumed in Brazil (whose privatization took place in 2022)

Key Takeaways (2/5)

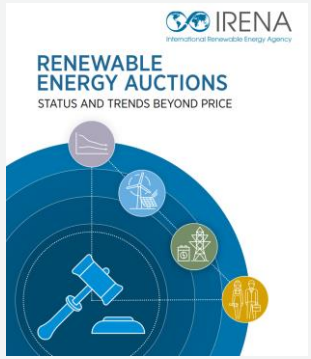
How did the Brazilian market pave the way for the integration of REs?

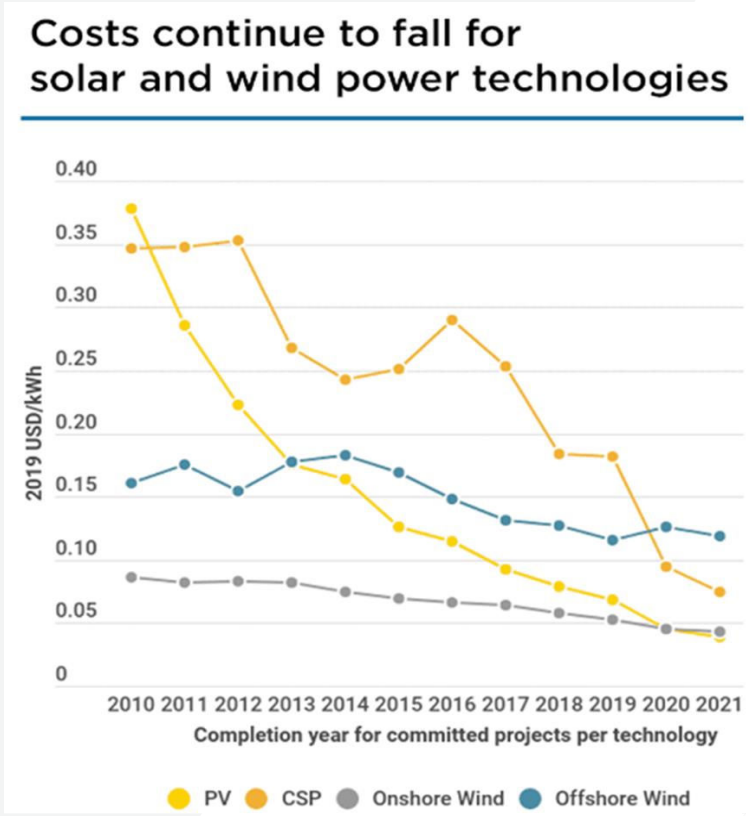
- Policy-driven subsidies ➔ support mechanisms for renewables
- 2002 Law defined a mandatory contracting of 3,300 MW of renewable until Dec 2006 through a 20-year PPA (“Proinfa”):
  - Equal quotas : 1/3 wind; 1/3 small hydro; 1/3 biomass
  - The cost of these contracts is collected from energy consumers through a system charge that is paid by all consumers (regulated and free), proportionally to their corresponding annual energy consumption
- Renewable generators with installed power of less than 30 MW only pay 50% of the Open Access Transmission Tariff (OATT)
- Additionally, a free consumer that buys energy from renewables has 50% discount on OATT
- Proinfa was replaced by renewable auctions ~2007/2008

System expansion via regulated auctions

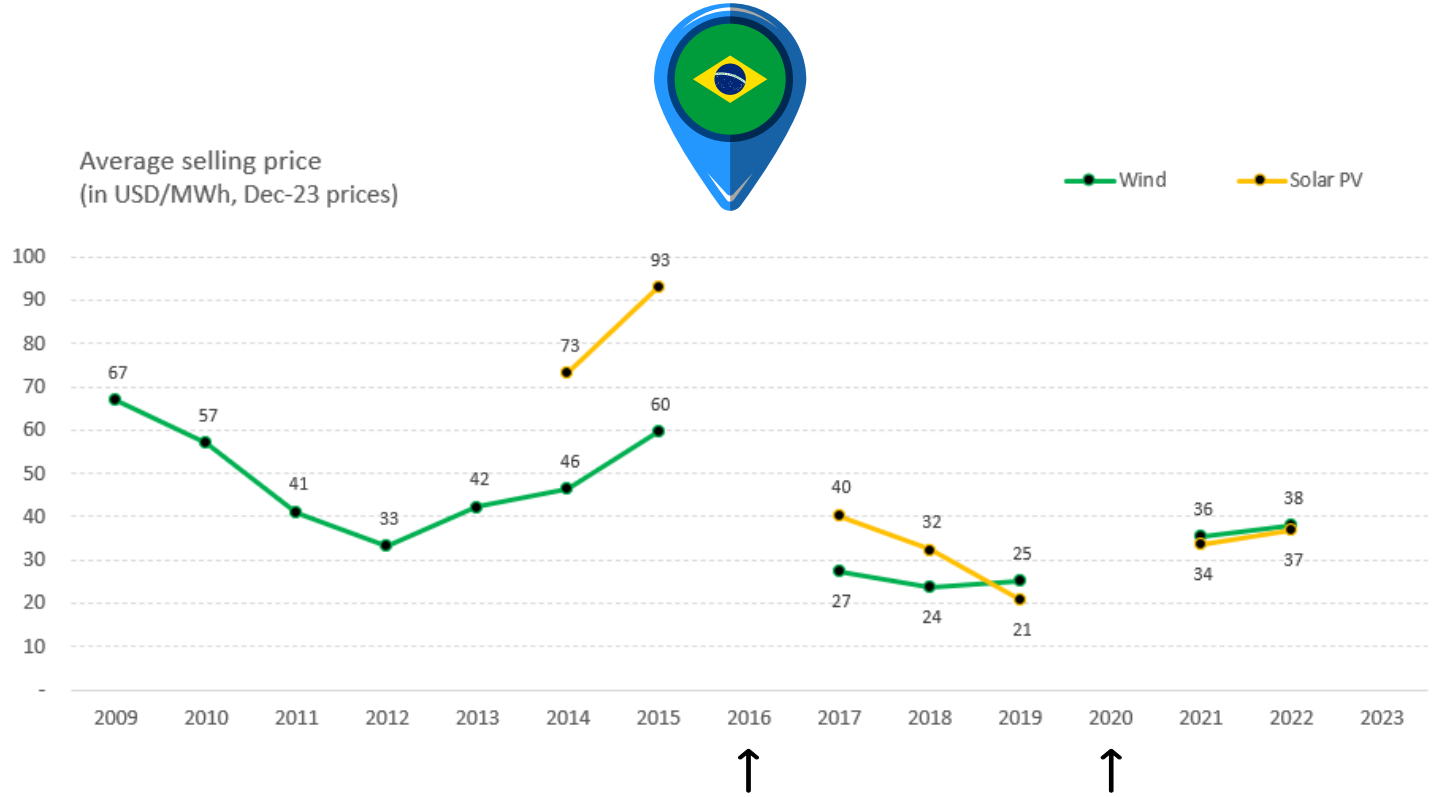
Current trends

- Plunging costs of wind and solar technology driven by (1) technological improvements, (2) favorable financing conditions offered by national development banks and (3) subsidies (OATT discounts)





Source: IRENA



No auctions for wind & solar were held in 2016 and 2020

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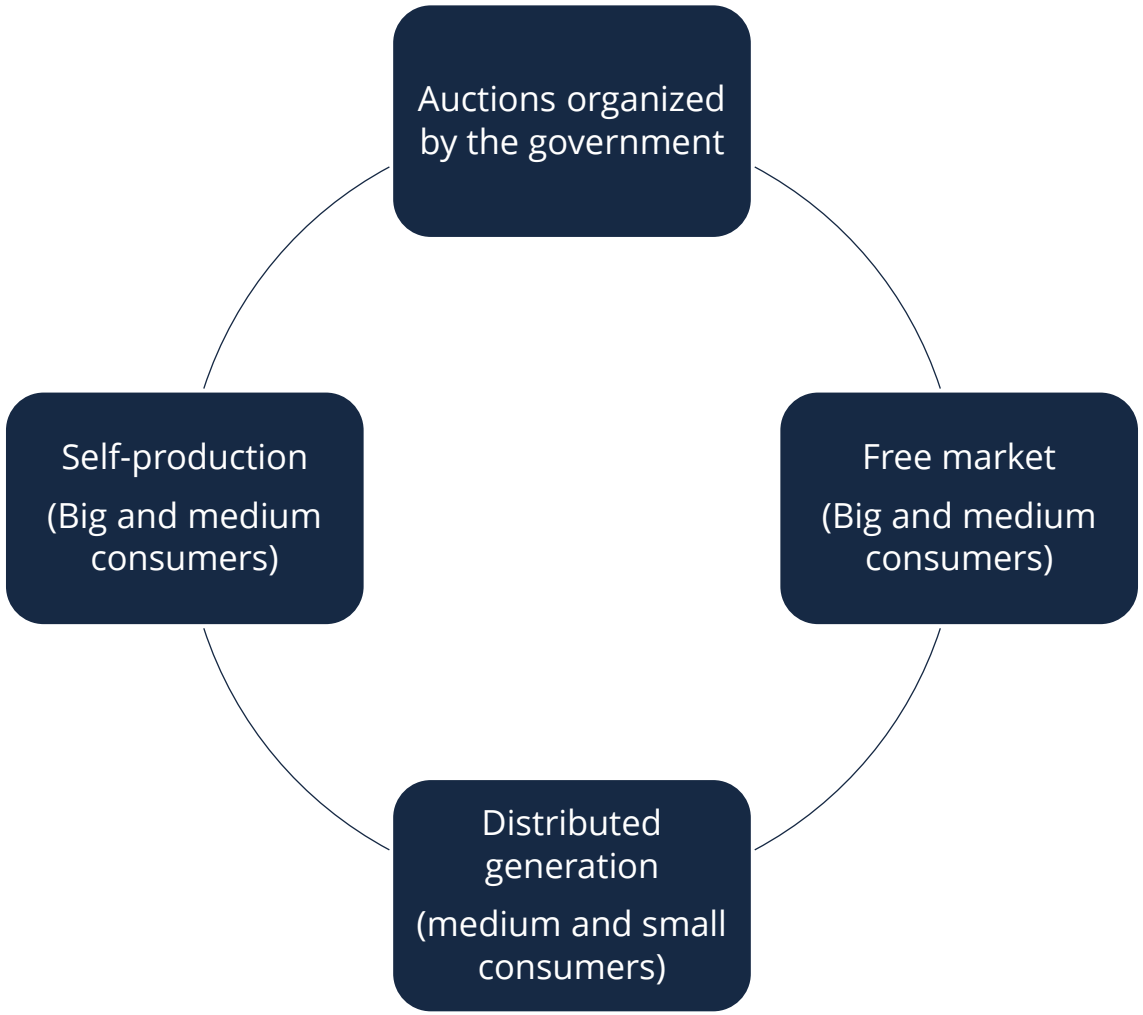
Different business models for selling energy



Top 10

Company	Most of the capital is	Installed capacity (MW)
Norte Energia	Private	11,233
Chesf	Private	10,460
Eletronorte	Private	9,863
Furnas	Private	9,423
Itaipu Binacional	Public	7,000
Petrobras	Public	5,797
Rio Paraná Energia	Private	4,995
Engie Brasil	Private	4,409
ESBR	Private	3,750
Santo Antonio Energia	Private	3,568

Source: ANEEL

Because sources are frequently located far from load centers, the system relies on a vast and robust transmission network

Large hydro power plants are spread out over the country's several river basins and are sometimes located in very remote areas.

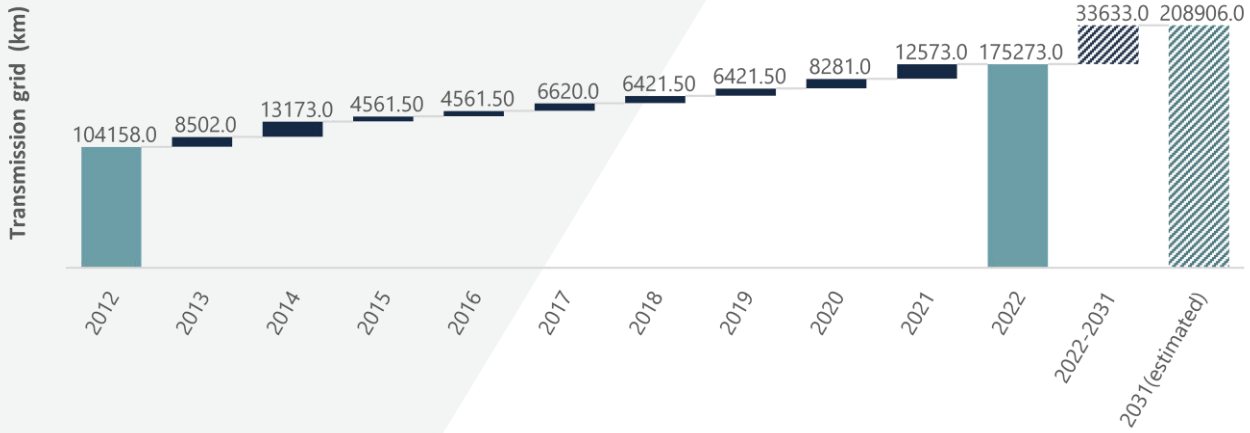
This vast network has several purposes, among which:

i) **to connect supply (generators) to demand centers**

ii) **link the country's power sources, some of which have complementary seasonal output profiles (portfolio composition); and**

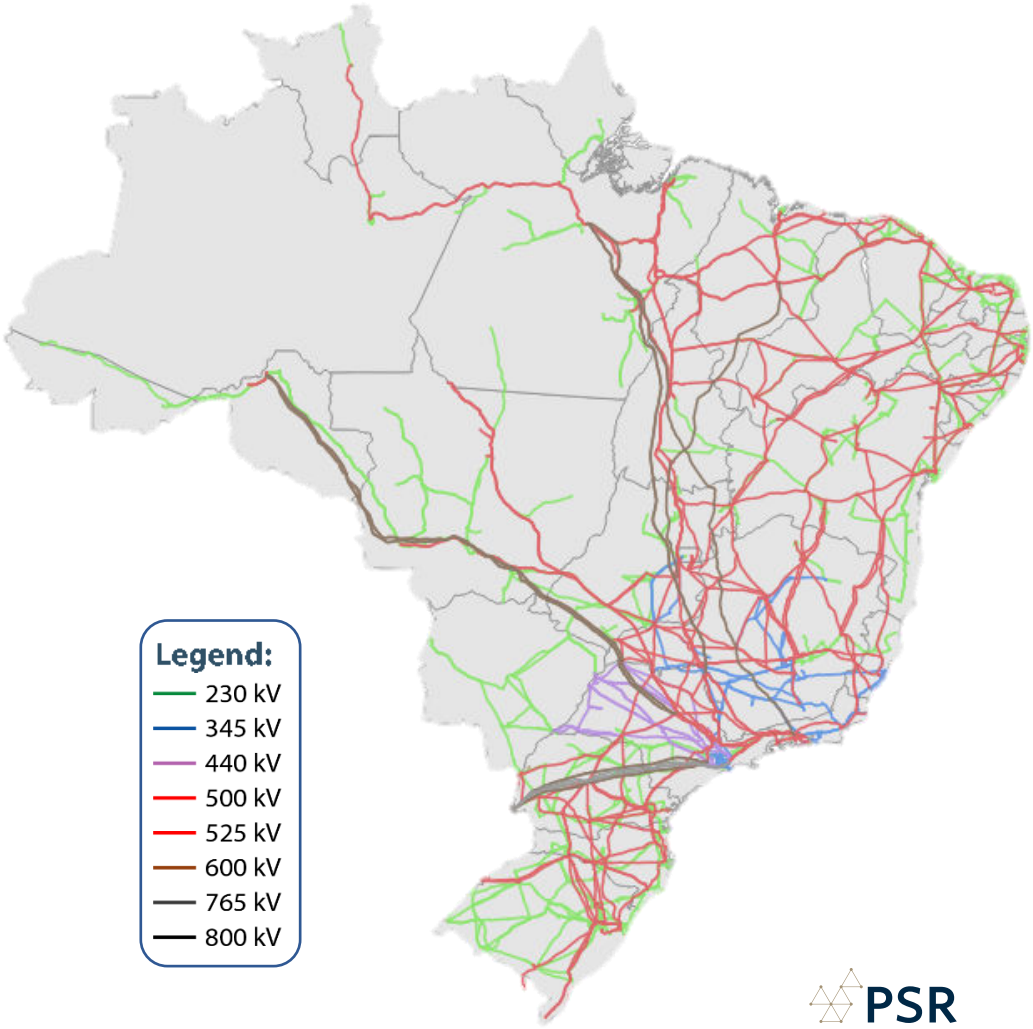
iii) **connect to power systems of neighboring countries.**

The network has grown significantly in recent years, with rates that have even exceed the growth of energy demand.



Source: EPE

Transmission Grid



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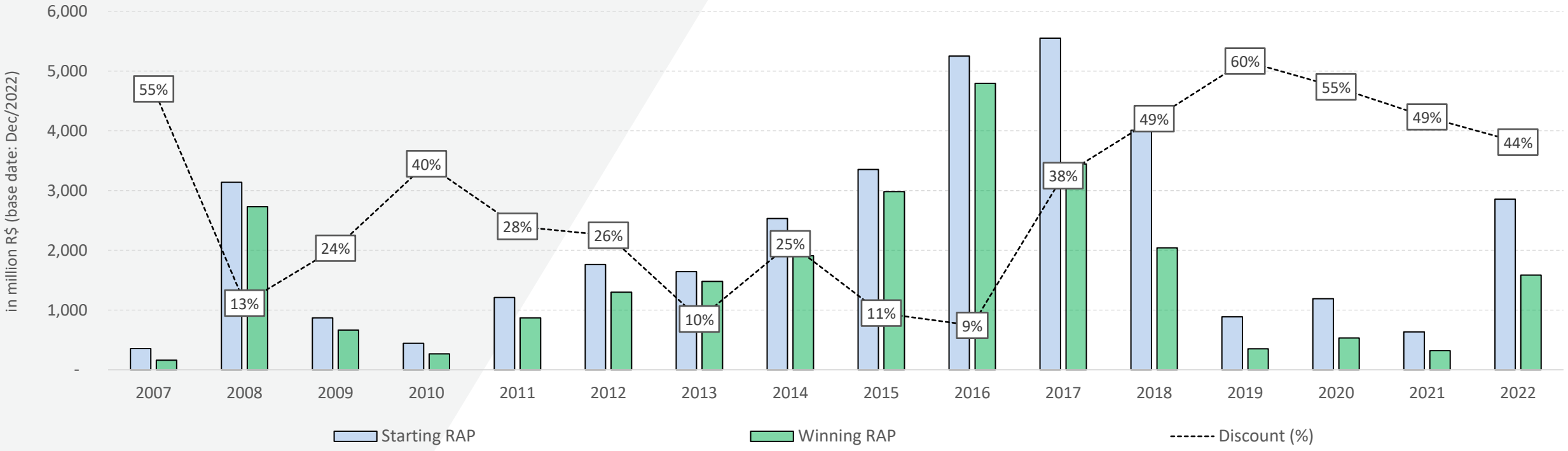
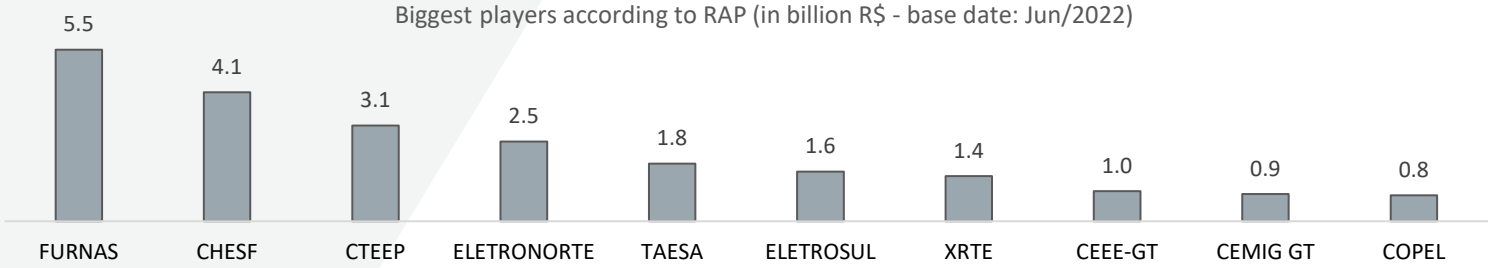
In the last 16 years, approximately 86,000 km of power lines and 223k MVA have been auctioned (~ R$ 185 billion in new investments)

More recently, the auctions have seen fierce competition



Biggest players according to RAP (in billion R$ - base date: Jun/2022)



Next auctions scheduled	
2024	June and December

Source: ANEEL

There are 53 distribution concessions spread thorough the country

Overview

Energy distribution is a public service performed upon federal public concessions regulated by ANEEL. The service comprises providing the network + selling energy to regulated (captive) consumers.

Distribution companies act in areas geographically defined in their concession contracts.

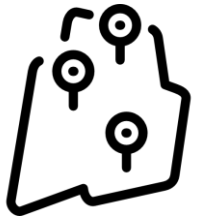
The characteristic of natural monopoly of the segment requires extensive regulation in order to emulate the incentives and results normally present in a competitive environment, and transfer benefits to the end consumers

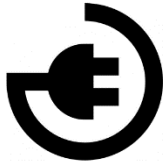
Currently, Brazil has 53 distribution concessions and 52 distribution licensees (which are very small).

Institutions

90 million consumers*

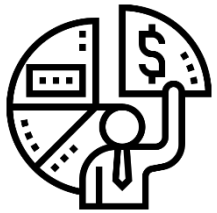
53 distribution concessions





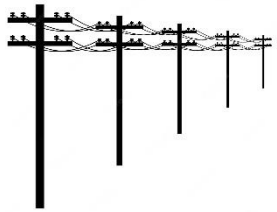
~529 TWh of total grid load

~77 TWh of total energy losses



64% Captive
36% Free

3.8 million km network



(*) Corresponds to approximately 210 million people.

Source: ANEEL and CCEE

The Regulated Market (ACR) & the Free Market (ACL)

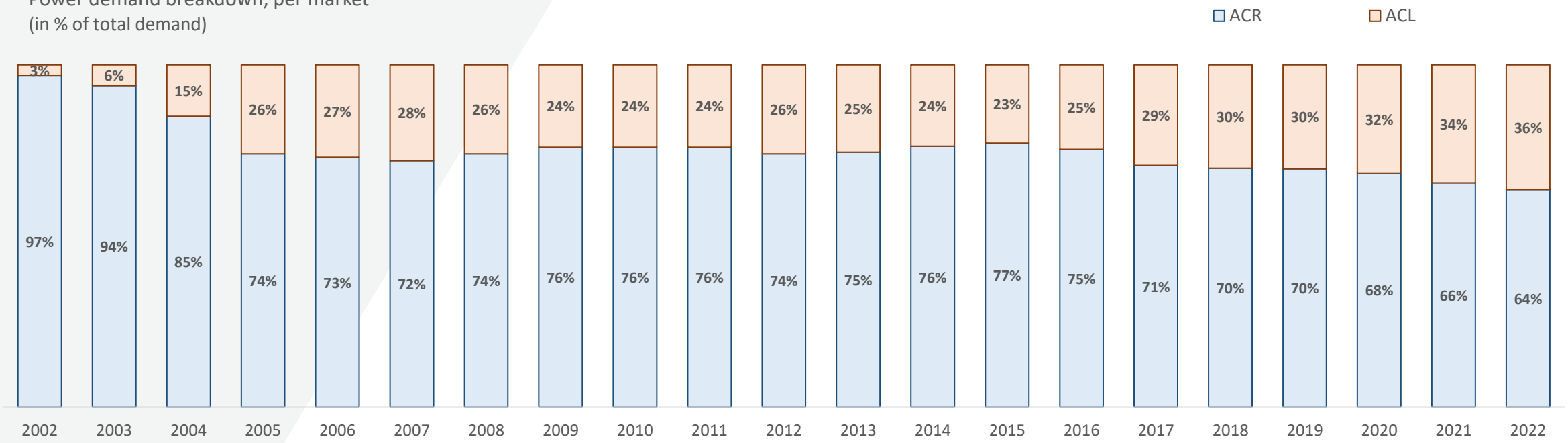
The Regulated Market (ACR):

- **Exclusive to distribution companies**
- **Standard long-term PPAs (15 to 30 years)**
- **Trading happens through government organized auctions**

The Free Market (ACL):

- **Free consumers & traders**
- **Bilateral PPAs traded over-the-counter**
- **PPAs have shorter terms – usually up to 6 years**

Power demand breakdown, per market
(in % of total demand)



Source: CCEE

Brazil's power sector is moving to full liberalization

1 Generation

Participation of private/public companies

ISO dispatches the resources

2 Transmission

Participation of private/public companies

ISO manages the grid

3 Distribution

Participation of private/public companies

4 Retail Services

Large/medium consumers are free to buy energy from energy traders.

Small consumers buy from distcos

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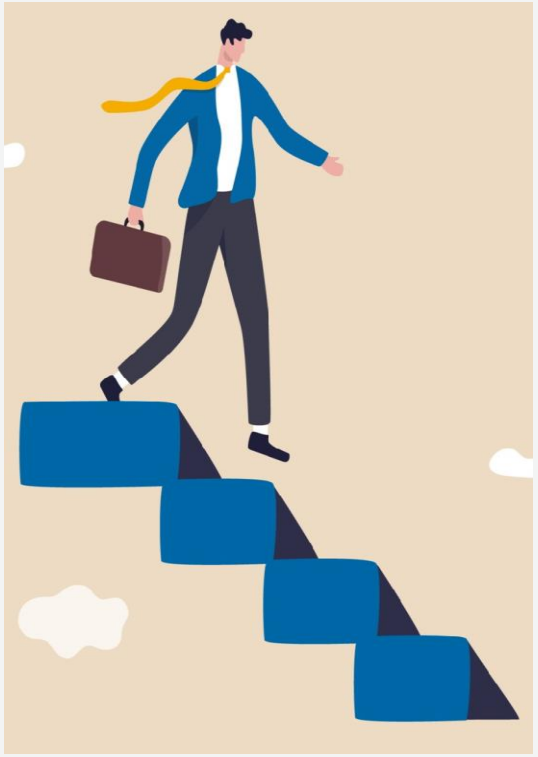
Since 2017 the country is discussing a full market liberalization



Voltage	Load	Conventional Free Consumer	Incentivized Free Consumer*
High	3 MW	Original	Original
	2,5 MW	From 7/19 on	
	2 MW	From 1/20 on	
	1,5 MW	From 1/21 on	
	1 MW	From 1/22 on	
	500 kW	**From 1/23 on**	
	< 500 kW	**From 1/24 on**	
Low		**Future**	**Future**

- The Free Market (ACL) is rapidly expanding as entry limits are reduced and consumers leave their local utilities in search of better prices

(*) Consumers that purchase energy from renewable sources, which have discounts in network usage costs.

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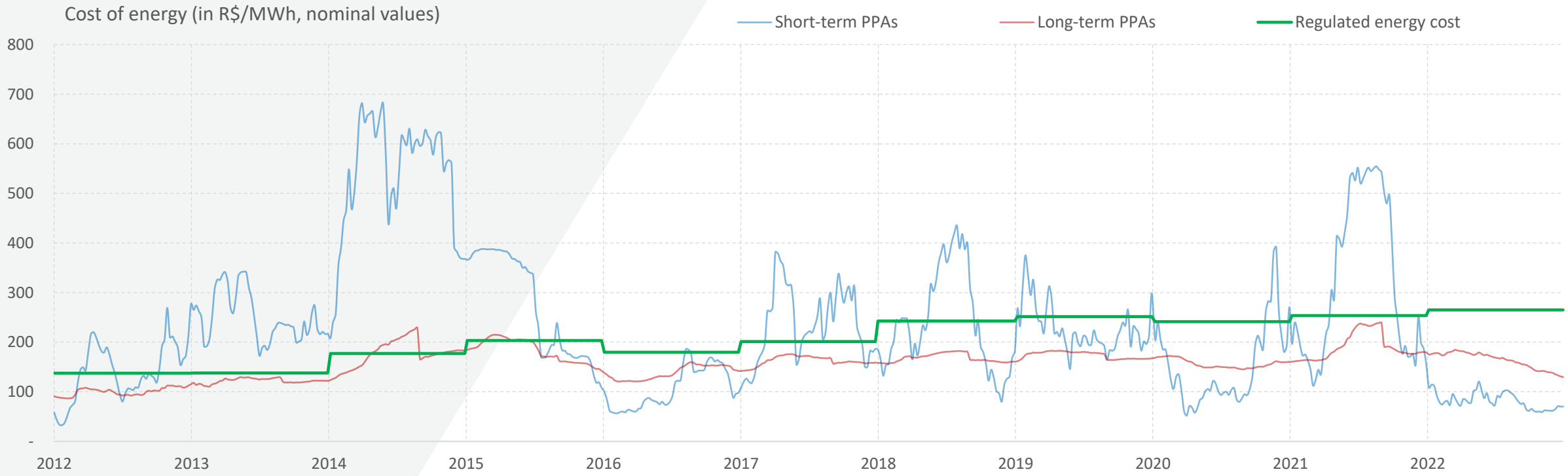
… as the cost of energy on the Free Market is more competitive than the regulated tariffs



It makes sense to move!

Free Market PPAs are currently cheaper than what local utilities are charging, which derives from their portfolio of long-term contracts.

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Source: DCIDE and ANEEL

Key Takeaways (3/5)

What challenges/bottlenecks are we encountering during transitions towards liberalization?

- The Free Market in Brazil is still a maturing market, where most transactions are over-the-counter (OTC) transactions.

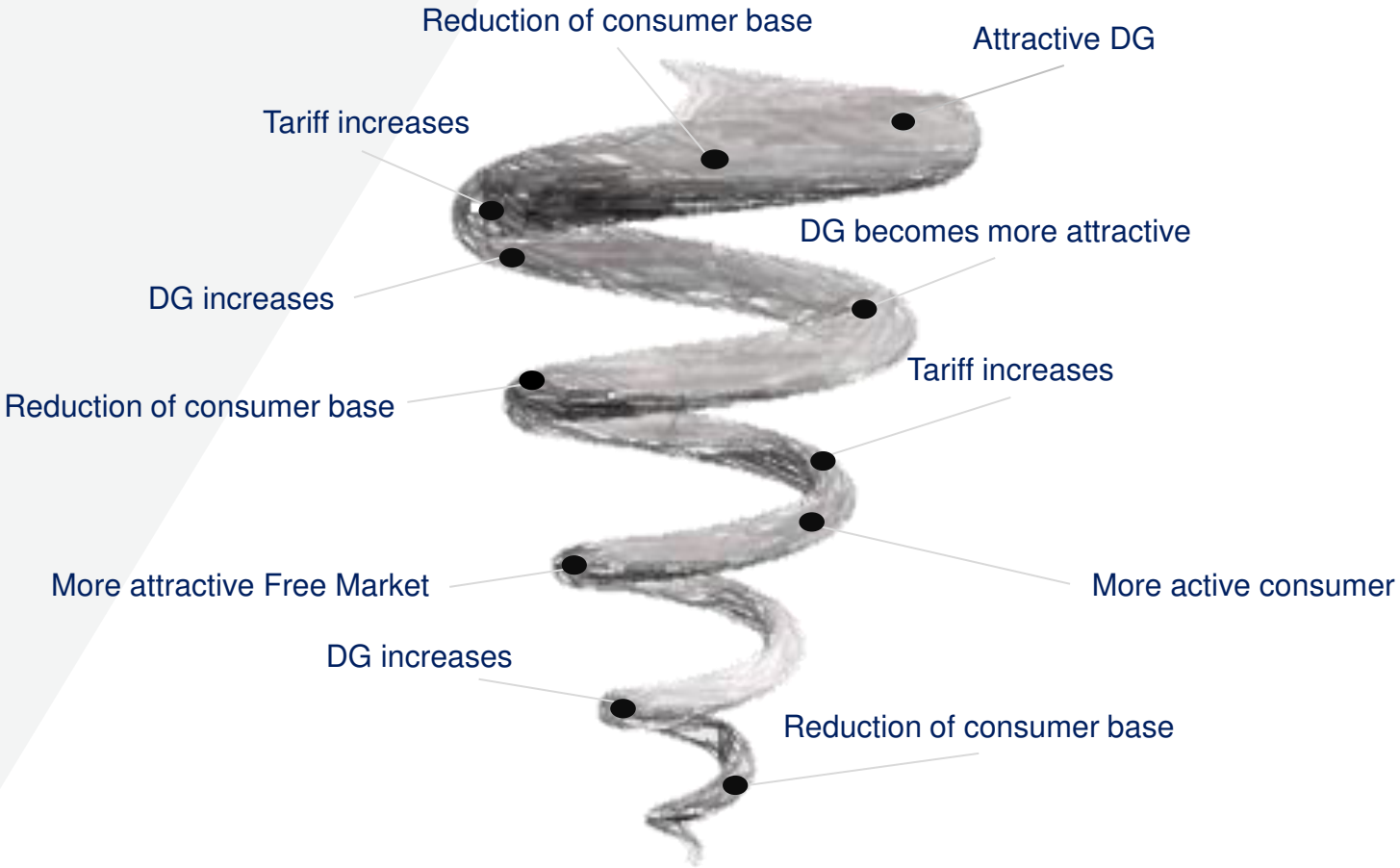
- As a result of this “unorganized” market, we have:
  - Too much information asymmetry
  - Low liquidity
  - Few financial products offered in the market

- A fundamental measure to assist in the consolidation of this market would be the creation of an energy exchange, where negotiations could be carried out. That way, it would have:
  - A credible price reference
  - Greater liquidity
  - Creation of new products (financial hedge)
  - Central counterparty

Key Takeaways (4/5)

What challenges/bottlenecks are we encountering during transitions towards liberalization?

- Recognize & avoid the “Death Spiral”



Who pays the bill?

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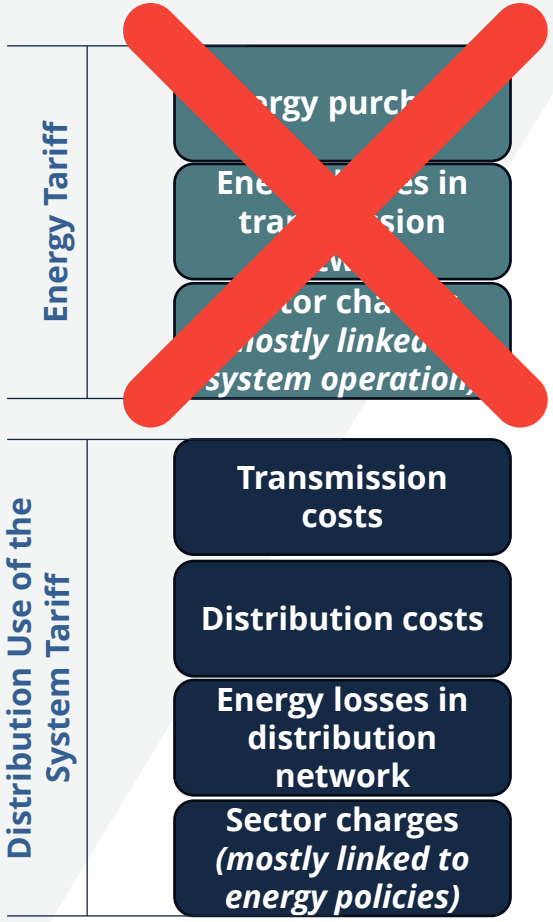
Key Takeaways (5/5)

Proposals?

Costs paid by regulated consumers



- One of the proposals is to create a sector charge to split the legacy costs between all the consumers of the system
- Note that in this case, each consumer will earn a charge but will gain their corresponding share of energy
- The natural consequence of this process is the need to change the role of distribution companies in Brazil so that they are no longer responsible for contracting energy at auctions and have only the wire function

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www.psr-inc.com

psr@psr-inc.com

+55 21 3906-2100