



The Brazilian Transmission Business model

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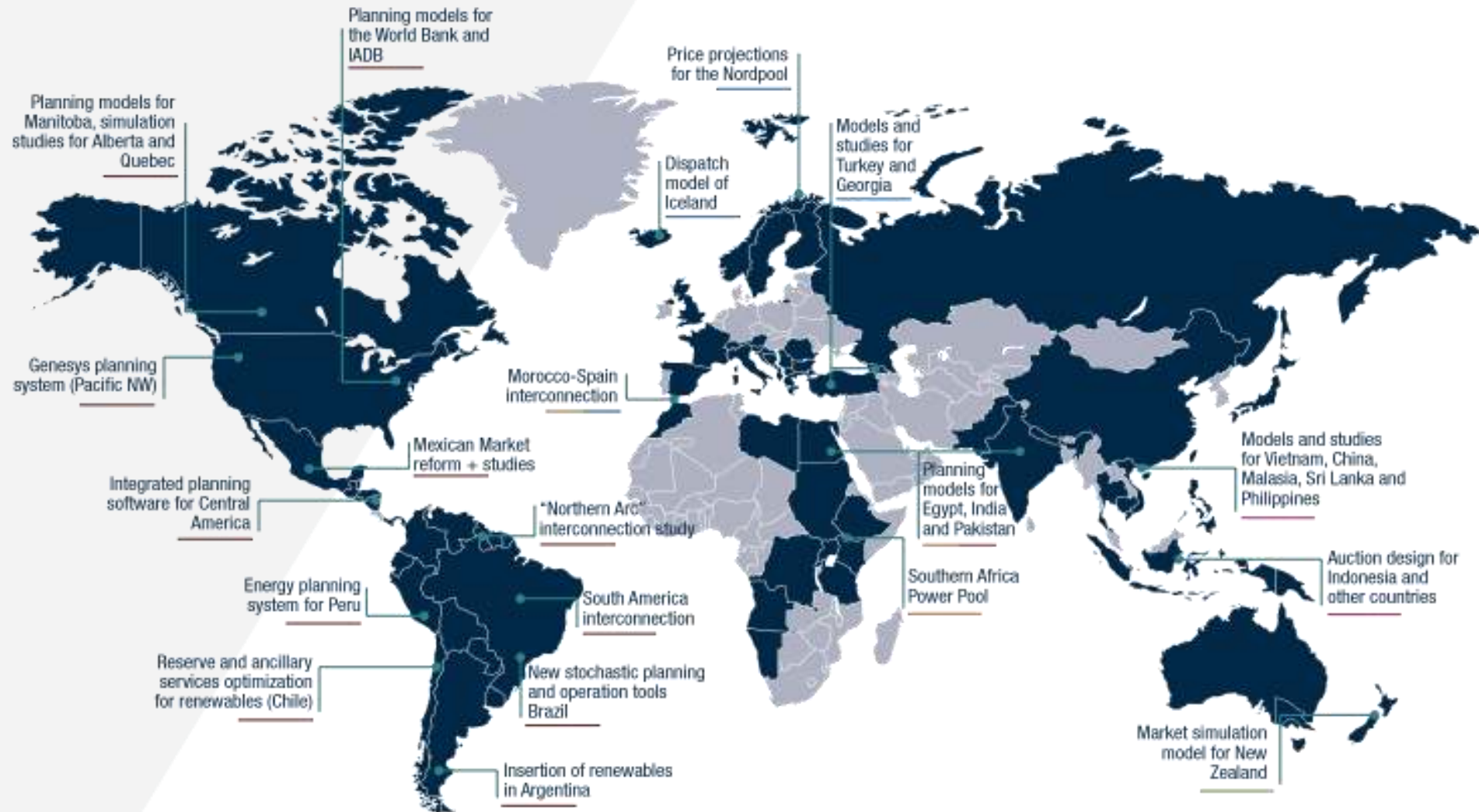
About PSR

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Our team has 140 experts, with advanced degrees in engineering, optimization, regulation, economics, energy systems and IT/data science.



PSR operates in more than 70 countries on all continents



Some topics here presented have been well documented in the literature in the past (reading from 3 to 3:15am)

Planning for Big Things in Brazil



Planning and Building Large-Scale Transmission Networks in Competitive Hydrothermal Systems: Technical and Regulatory Challenges

By Luiz A. Barroso, Fernando Pereira, Luis M. Thomas, and Mario R. Pereira

Flexible Connections



Solutions and Challenges for the Integration of Renewables in South America

Abstract—Modernizing the power grid infrastructure is a key to the success of the energy transition in South America. This paper discusses the challenges and solutions for the integration of renewable energy sources in the region. It highlights the need for flexible connections and the role of transmission expansion planning in addressing these challenges. The paper also discusses the impact of regulatory and institutional factors on the development of the power grid.

By Hugh Rudnick, Luiz A. Barroso, Daniel Clemen, David Watten, and Rafael Ferreira

By Rafael de Sa Ferreira, Hugh Rudnick, and Luiz Barroso



The Expansion of Transmission

Abstract—The expansion of transmission infrastructure is a key to the success of the energy transition in South America. This paper discusses the challenges and solutions for the expansion of transmission infrastructure in the region. It highlights the need for flexible connections and the role of transmission expansion planning in addressing these challenges. The paper also discusses the impact of regulatory and institutional factors on the development of the power grid.

Combinatorial and Simultaneous Descending Auctions for Electricity Transmission Concessions

By Rafael de Sa Ferreira, Luiz A. Barroso, Daniel Clemen, David Watten, and Luis A. M. Pereira

Abstract—This paper presents a novel approach to the allocation of transmission concessions. It combines combinatorial and simultaneous descending auctions to address the challenges of allocating multiple concessions simultaneously. The paper discusses the design of the auction mechanism and the impact of regulatory and institutional factors on the development of the power grid.

1. INTRODUCTION

Managing Uncertainty in Implementation Times of Competitively-Procured Transmission via Risk-Sharing and Winner Selection Functions

By Rafael de Sa Ferreira, Luiz A. Barroso, Daniel Clemen, David Watten, and Luis A. M. Pereira

Abstract—Modernizing the power grid infrastructure is a key to the success of the energy transition in South America. This paper discusses the challenges and solutions for the implementation of competitively-procured transmission via risk-sharing and winner selection functions. The paper highlights the need for flexible connections and the role of transmission expansion planning in addressing these challenges. The paper also discusses the impact of regulatory and institutional factors on the development of the power grid.

Index Terms—Transmission implementation, risk-sharing, winner selection, principal-agent approach, competitive bidding.

1. INTRODUCTION

TRANSMISSION implementation delays are a major challenge for the power industry. This paper discusses the challenges and solutions for the implementation of competitively-procured transmission via risk-sharing and winner selection functions. The paper highlights the need for flexible connections and the role of transmission expansion planning in addressing these challenges. The paper also discusses the impact of regulatory and institutional factors on the development of the power grid.

Transmission Expansion Planning under Consideration of Uncertainties in Facility Implementation Times

By Rafael de Sa Ferreira, Luiz A. Barroso, Daniel Clemen, David Watten, and Luis A. M. Pereira

Abstract—This paper presents a novel approach to the expansion of transmission infrastructure under uncertainty in facility implementation times. It combines transmission expansion planning with risk-sharing and winner selection functions to address the challenges of allocating multiple concessions simultaneously. The paper discusses the design of the auction mechanism and the impact of regulatory and institutional factors on the development of the power grid.

1. INTRODUCTION

TRANSMISSION expansion planning is a key to the success of the energy transition in South America. This paper discusses the challenges and solutions for the expansion of transmission infrastructure under uncertainty in facility implementation times. The paper highlights the need for flexible connections and the role of transmission expansion planning in addressing these challenges. The paper also discusses the impact of regulatory and institutional factors on the development of the power grid.

And others have just been covered in our PSR Energy Report of April 2023

ENERGYREPORT

Planning transmission for a net zero future



 SCAN ME

ENERGY REPORT

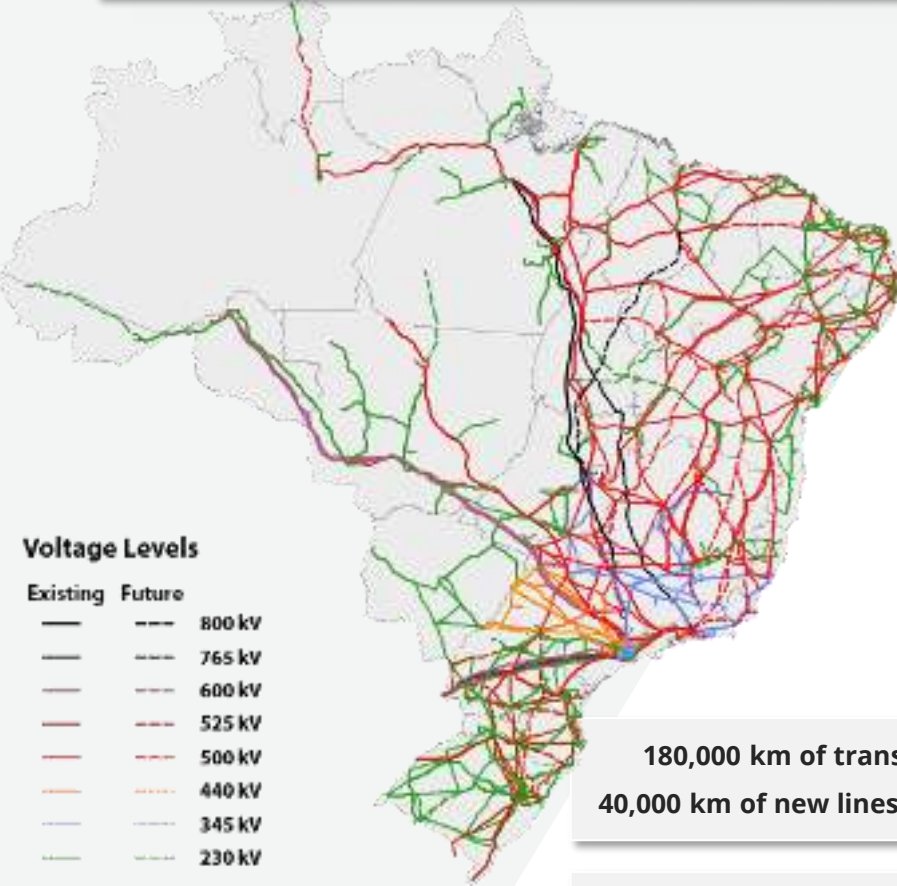
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Topics

- **The transmission business model**
- **Lessons learned**
- **Current challenges**
- **Conclusions**

Brazil's electricity supply mix is mostly renewable and highly interconnected

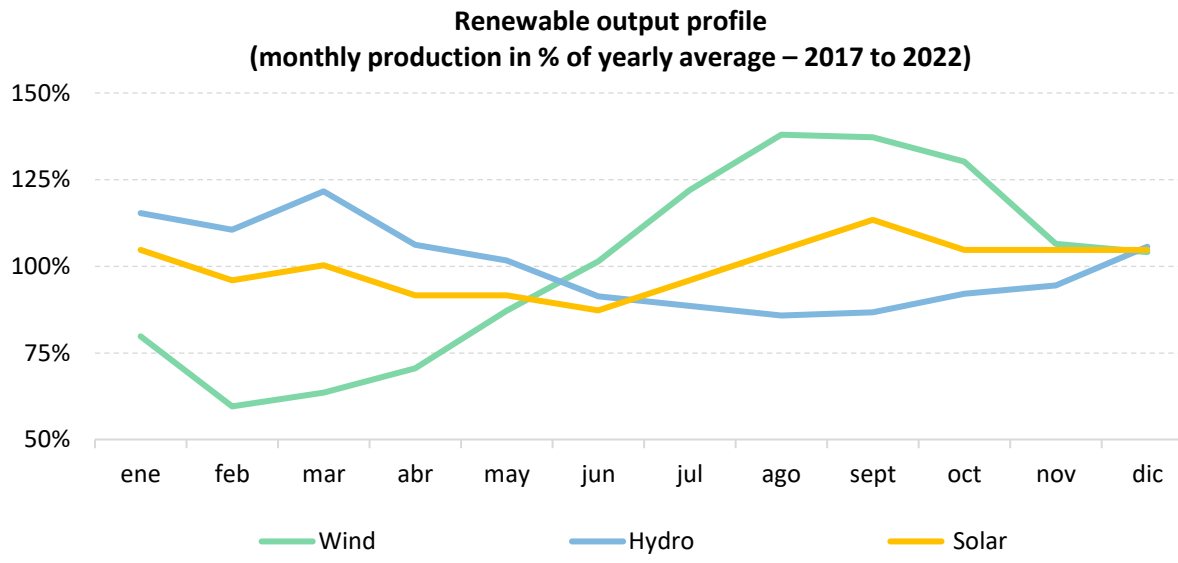
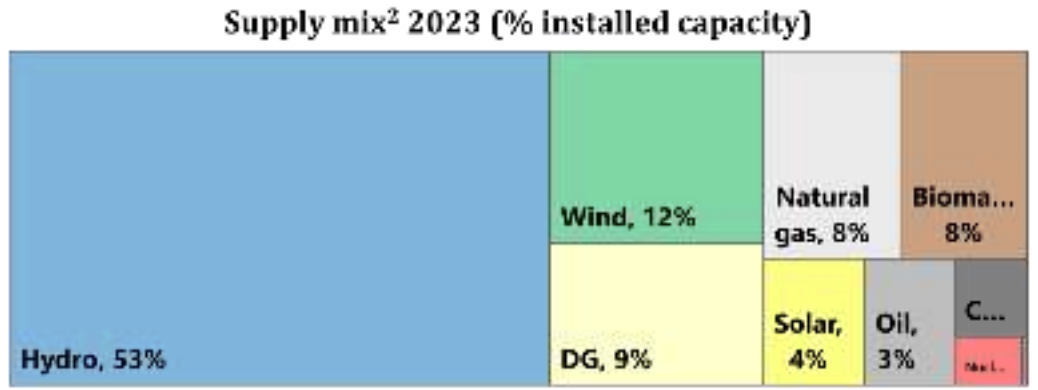
The transmission network is part of the portfolio of complementary renewable generation sources.



180,000 km of transmission lines¹
40,000 km of new lines added since 2016

The Integrated National System (SIN) was created in 1999.

[1,3] source: National System Operator (ONS)
[2] source: ANEEL



The transmission business model

The transmission, planning and operation is **centralized**

COORDINATION

Central planning

Least cost expansion planning

- Aim to optimize the use of system resources
- Aim to maximize systemic benefits

The implementation of assets is **decentralized**

EFFICIENCY

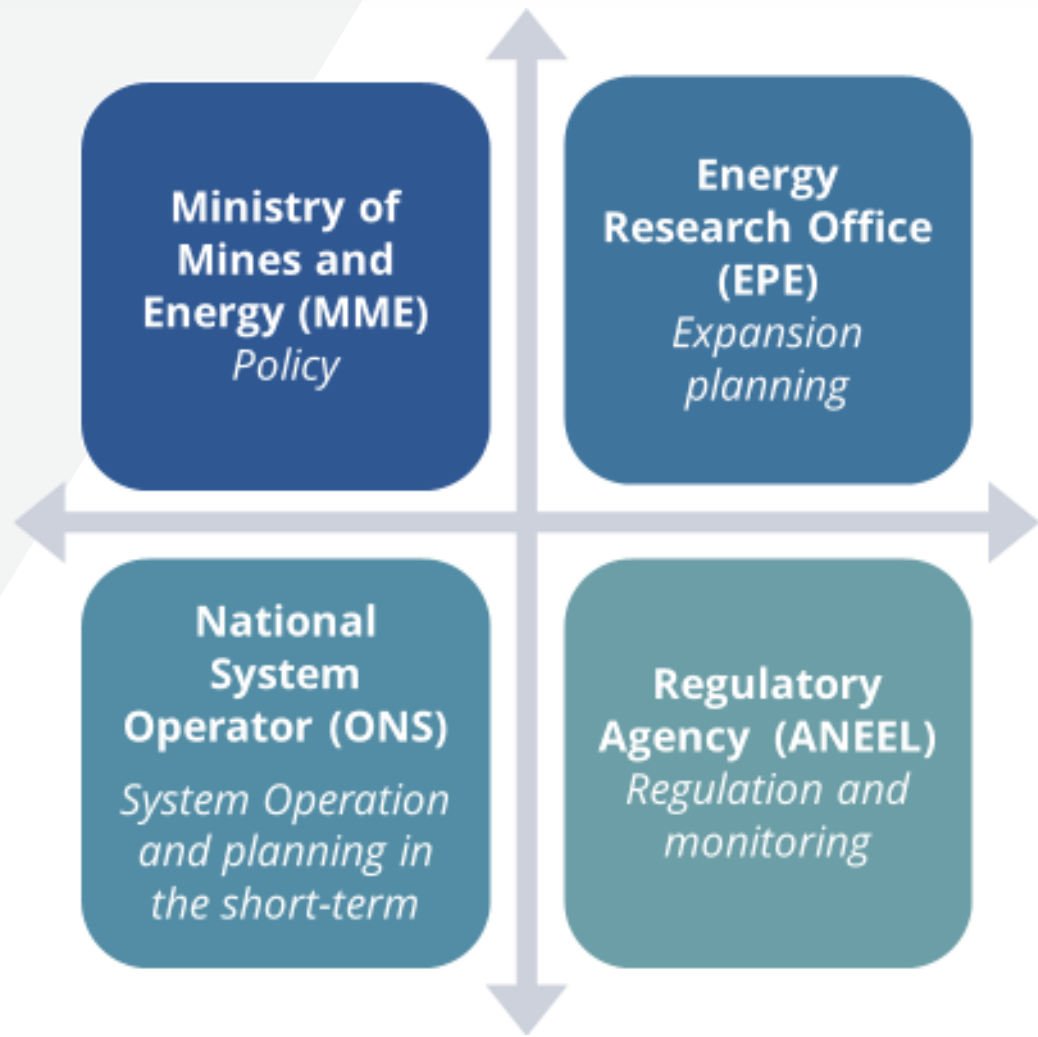
Transmission auctions

Auctions - decentralized execution:

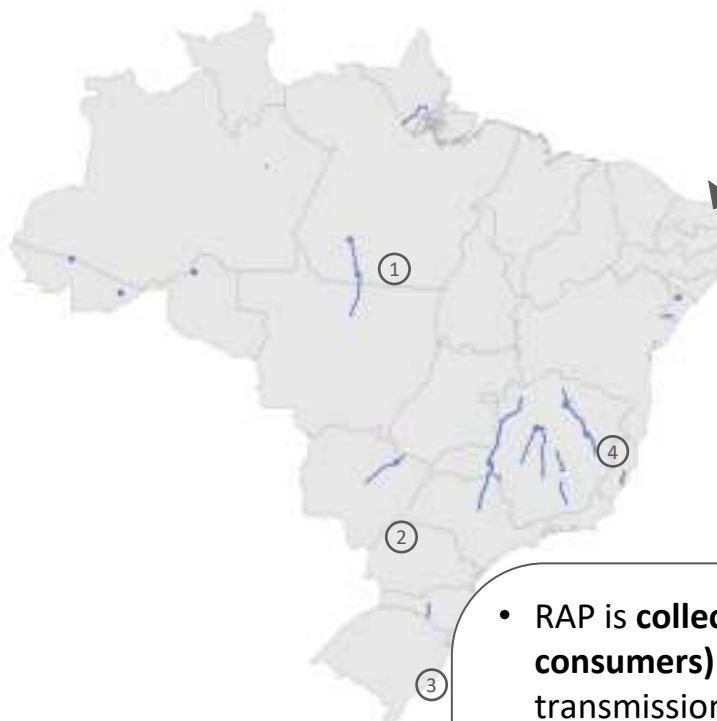
- Price discovery for the CAPEX
- Assigning responsibility for construction and O&M to transmission companies

Institutional framework

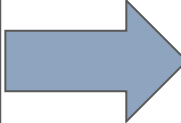
In the transmission regulatory model, planning the transmission expansion, execution of construction and operations assets, and operating system are decoupled from each other.



Transmission auctions as a **low-risk business model**: long-term concessions awarded through public auctions based on a revenue cap model



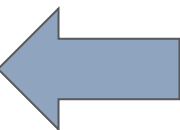
- EPE plans the expansion of the grid according to system needs.
- The (new) assets needed are divided into lots and put up for auction.



- Players compete for an annual revenue stream (RAP¹) granted to build, maintain and operate the assets.
- ANEEL sets the auction's **cap for RAP**
- Whoever offers the **smallest RAP**, wins the right to develop the projects and becomes a "Transco"



- RAP is **collected from all grid users (generators & consumers)** through a charge known as the transmission tariff (**TUST**).
- **Credit risk is negligible** due to diversification.
- ANEEL may (unilaterally) require that certain **improvements or reinforcements** are implemented, in which case it will grant an additional RAP.
- At the **end of the concession, assets are reverted** to the State but can also be renewed by ANEEL.



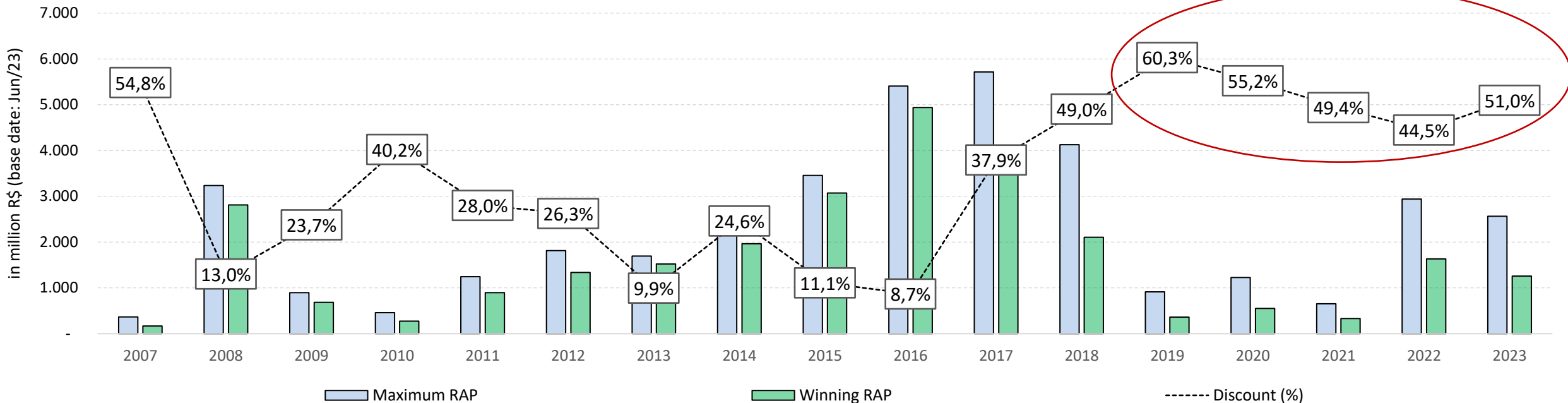
- **30-year concession** contracts are awarded.
- Transco commit to **build, maintain and operate** the assets.
- In return, they are paid a **fixed revenue stream**, starting at the asset's COD, is **adjusted for inflation** on a yearly basis, and **revised every 5 years**².
- Revenues are independent from the actual power flow through the facilities (**there is no volume risk**).
- Outage events can temporarily reduce the RAP (**penalty for unavailability**).

[1] RAP stands for Annual Allowed Revenue (*Receita Anual Permitida*, in Portuguese).

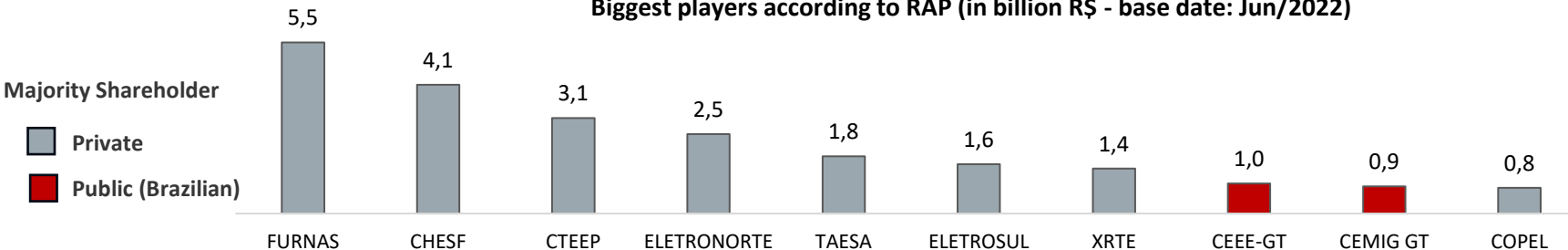
[2] Revisions, which consist in updating the regulatory cost of debt and operating & maintenance costs, are intended to share potential gains derived from technological improvements or better macroeconomic conditions with the public.

In the last 16 years, approximately 86,000 km of high-voltage lines and 223k MVA have been auctioned (~ USD 37 billion in new investments)¹¹

More recently, the auctions have seen fierce competition



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



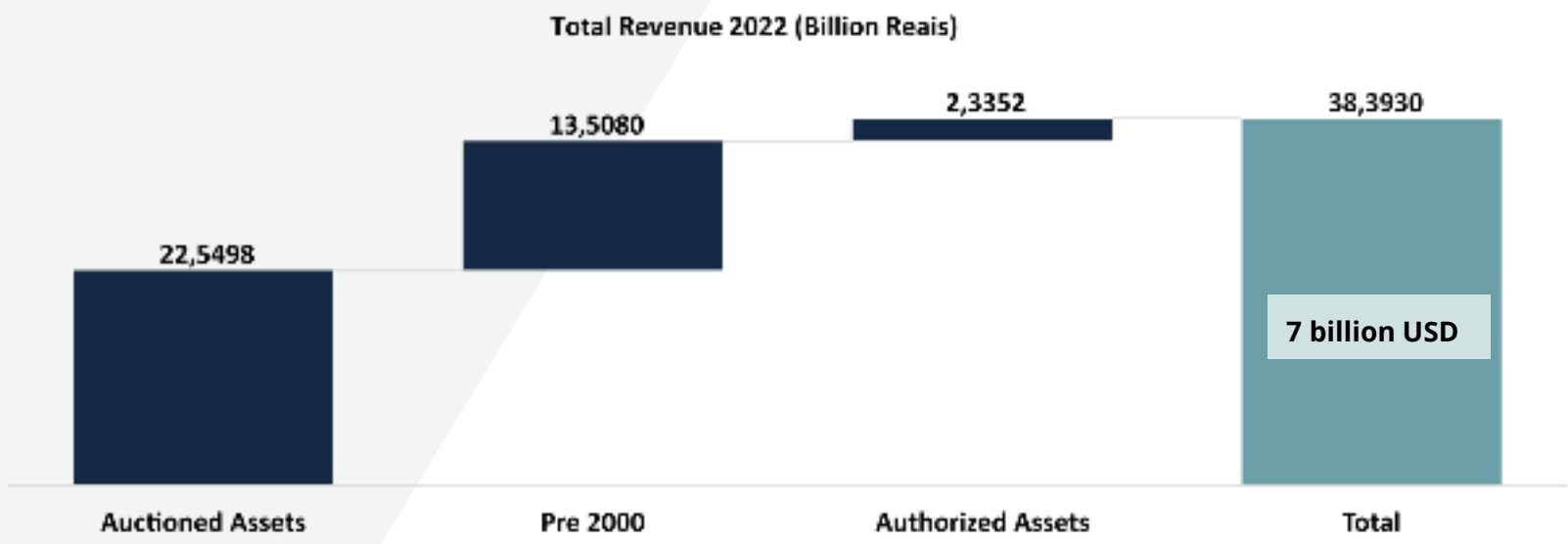
Next auctions scheduled	
2023	December
2024	March and September



Besides the auctions, new transmission facilities can be authorized

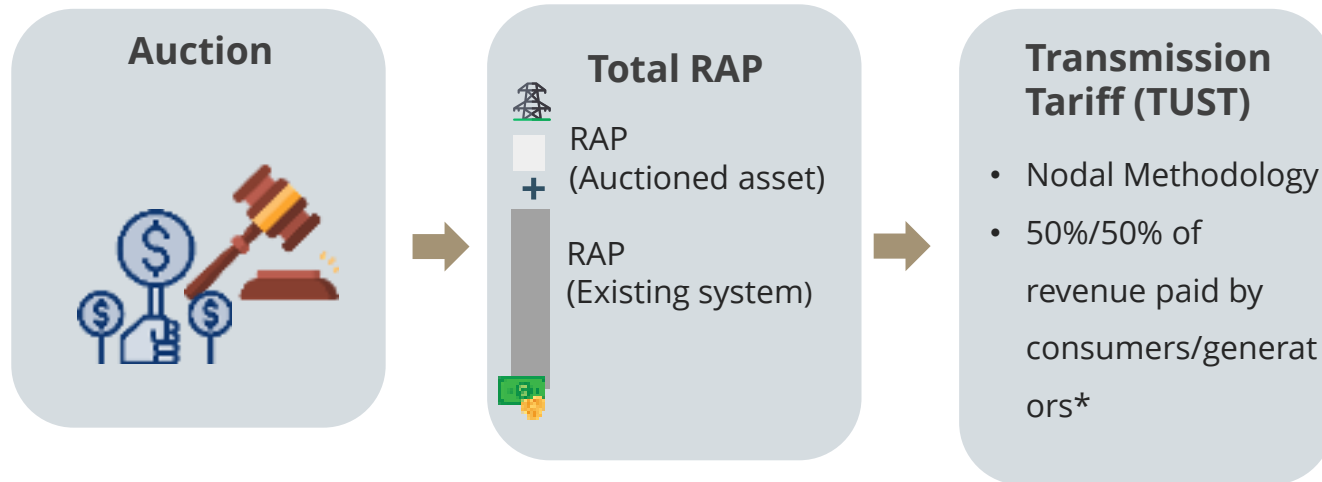


Currently, the auctions assets represent most of the total revenue of transmission system



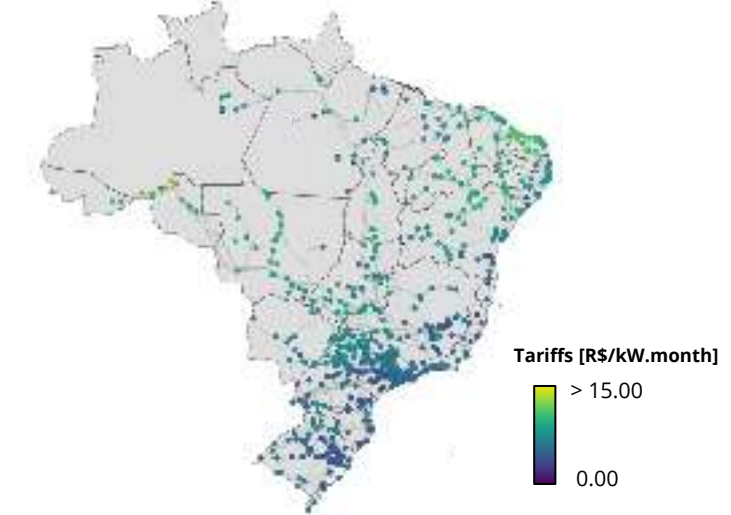
The tariffs calculated to pay the transmission revenue have a locational signal

Important locational signal for an optimal generation expansion

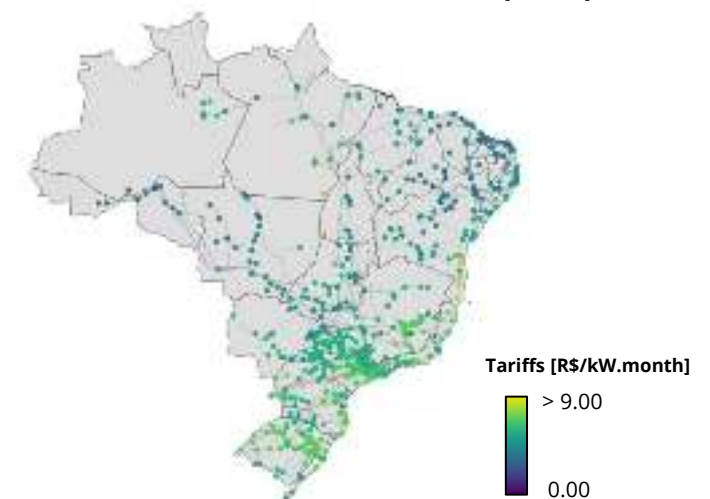


*Some mechanisms are adopted to mitigate the TUST volatility risk for generators

Generators Transmission Tariff (2020)

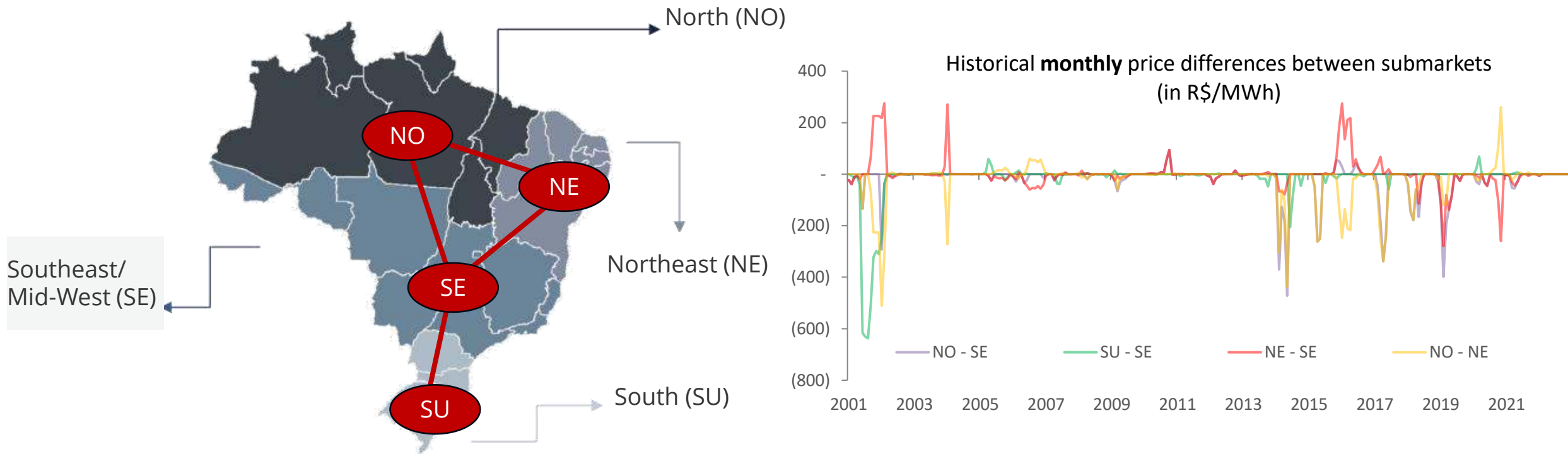


Consumers Transmission Tariff (2020)



The spot price (PLD) is zonal and indicates the transmission congestions

Spot prices (or PLD, in Portuguese) are structurally the same across the different zones. However, transmission congestions in the main interconnections may lead to price differences, as shown in the historical record below



The interconnection limits are defined by the system operator to ensure the proper operation and guarantee the security and reliability of the system.

This regulatory transmission framework has ensured an efficient and dynamic expansion of the transmission segment

In 2012



97,000 km of transmission lines



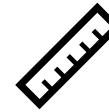
73 different transmission companies



Biggest players in terms of revenue (all private)

#	Transmission Company
1	FURNAS
2	ISA-CTEEP
3	CHESF
4	ELETRONORTE
5	ELETROSUL

In 2022



180,000 km of transmission lines



198 different transmission companies

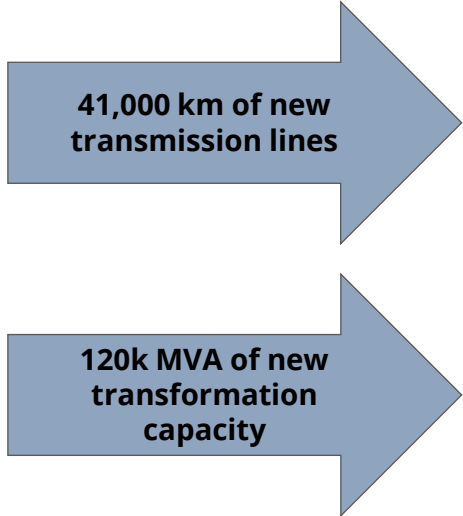
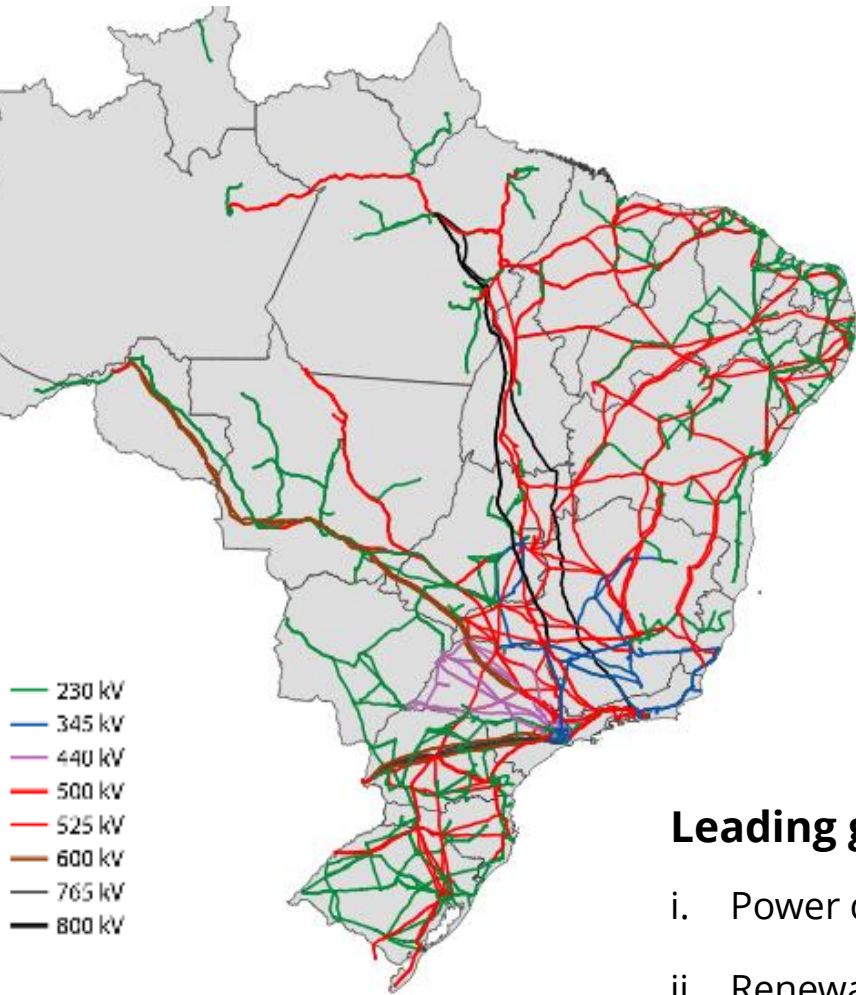


Biggest players in terms of revenue (all private)

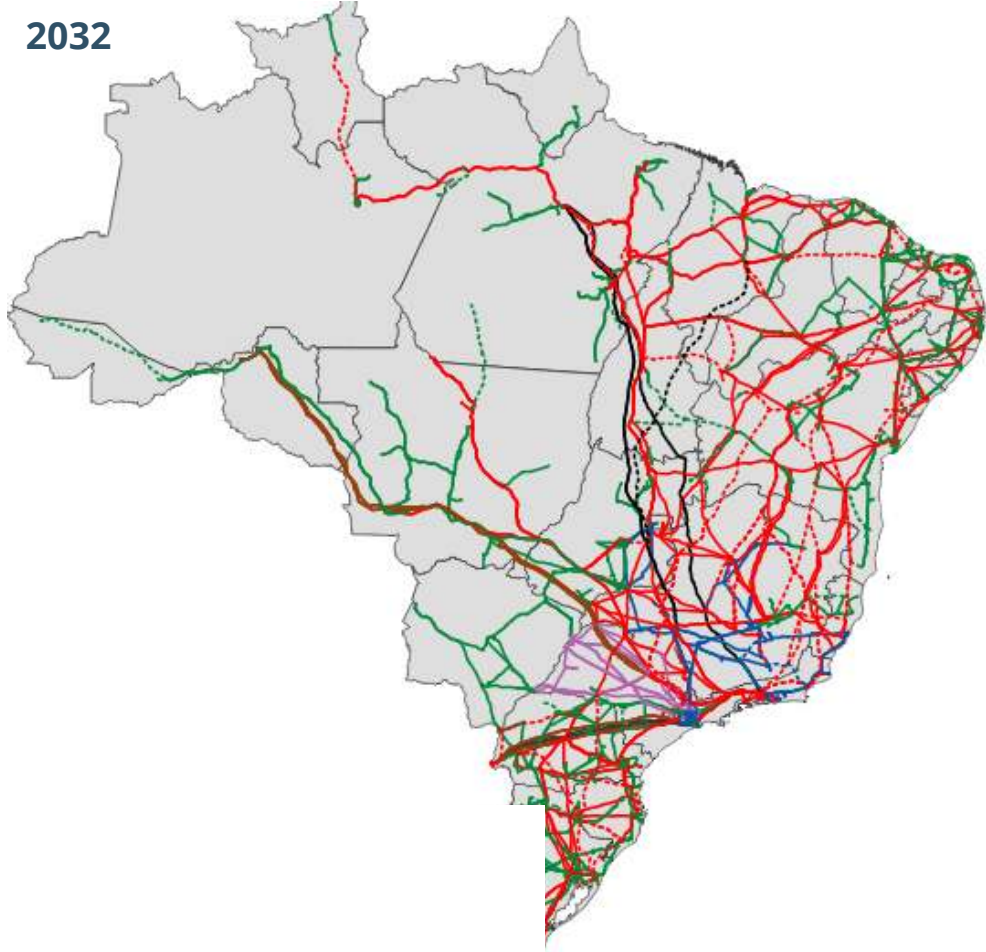
#	Transmission Company
1	FURNAS
2	CHESF
3	ISA-CTEEP
4	ELETRONORTE
5	TAESA

The grid is expected to grow significantly over the next 10 years, requiring **USD 20 billion** of new investments

2022



2032



Leading growth drivers:

- i. Power demand growth
- ii. Renewables' growth
- iii. Reliability & resiliency.

Lessons Learned: Reduction in competition in the auctions during 2012 - 2016

The Problem

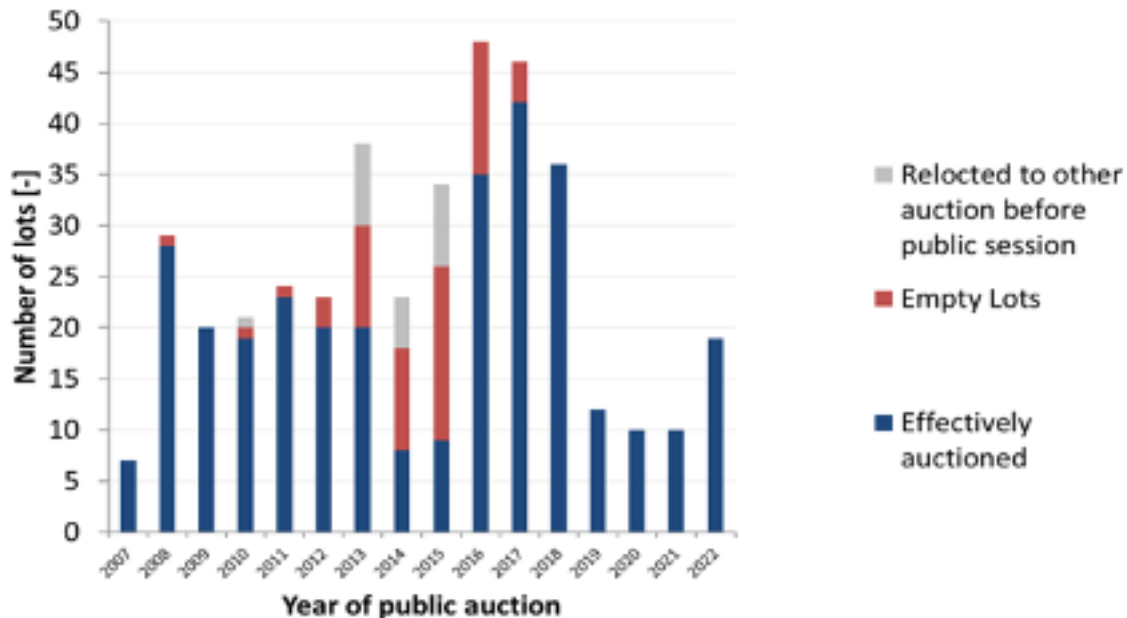
Delays in environmental licensing became a systematic problem in the transmission sector, raising investors' perception of risk → **increase of empty lots in the auctions in 2012**



The Solution

Regulatory + Planning effort to decrease investors risk perception

- Increased regulatory period to start commercial operation
- Incentives to anticipate the entry into operation of assets
- EPE reinforced the preliminary studies for the auction to expose more clearly the social and environmental risks to which the investor who acquire certain lot would be exposed.



Lessons Learned: The significant increase in the number of delays in the implementation of transmission facilities

The Problem

Recurrent delays in the transmission implementation schedules have been a great concern

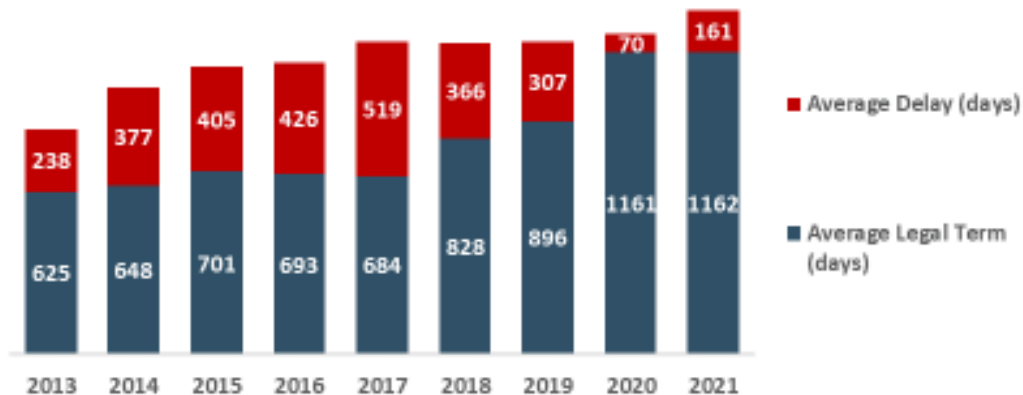


The Solution

Regulatory effort to ensure efficiency in construction

- Review of penalties rules
- Improvements in inspection processes of transmission services
- Requirement of performance bonds with milestones according to the works schedule
- Preclusion of the companies that were behind schedule in the transmission auctions

Average Construction Execution Time (Days)



Lessons Learned: Mismatch between generation and transmission expansion

The Problem

Period for the transmission system to be planned, auctioned, and start operation → **7 years**

Period for the wind and solar to be planned, and start operation → **less than 3 years**

Those 4 years of difference led to greater transmission bottlenecks, and impacting the generation expansion

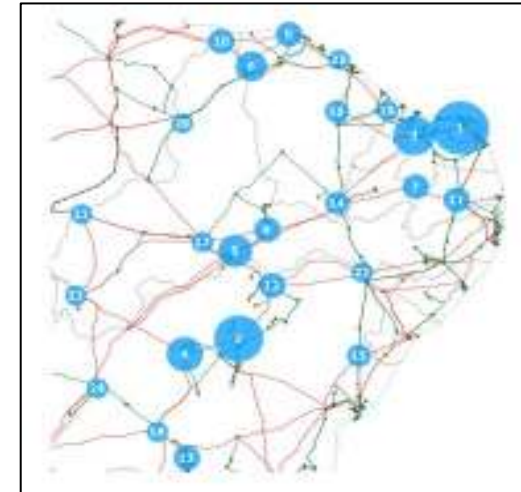


The Solution

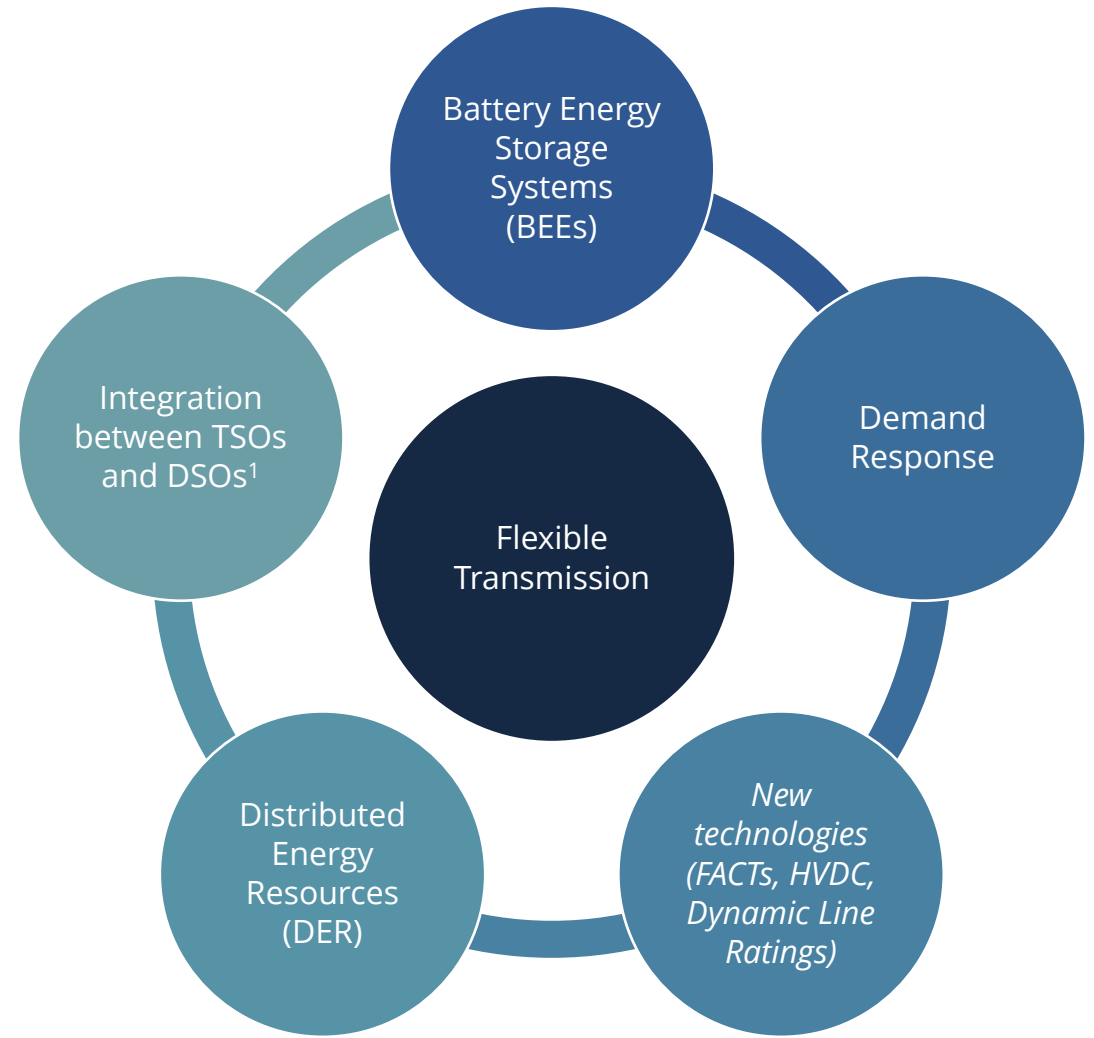
Proactive transmission expansion

The system planner (EPE) started to identify the most likely locations of interest of new generators and to plan the main “highways” in advance of generation with decision-making under uncertainty techniques

Identification of hotspots for generators considering land conditions, and irradiation/wind factors.



Current Challenges: The increase of renewables requires transmission to be flexible



[1] TSOs: Transmission System Operators | DSOs: Distribution System Operators

[2] Flexible Alternating Current Transmission Systems

Current Challenges: How to plan a transmission system with flexibility

R&D project with ISA-CTEEP: Integrated and Flexible Planning of Transmission Systems

Detailed case studies were carried out for the systems of Brazil, Colombia, Peru and Chile.

Planning methodology with conventional equipment (lines, transformers etc.) and flexible resources such as BESS, FACTS, and HVDC



Current Challenges: How to unlock the interconnection queues

Current Connection Process

Currently it is a process with minimal “cost of regret” for the generator
→ incentive to speculative projects

In 2021, 21 GW of generations projects entered the interconnection queue, and only 7 GW continued until the end

The “gold rush”

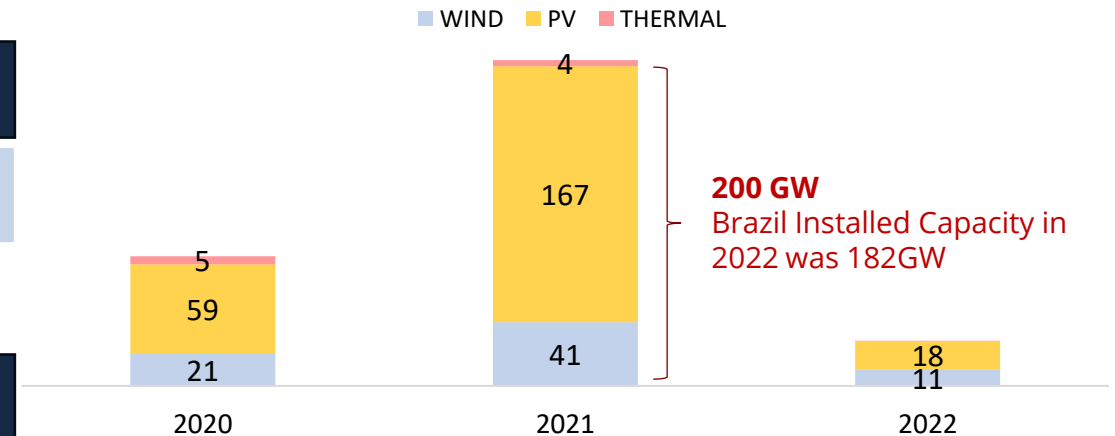
A specific date to terminate some renewable subsidies led to a rush by generators to obtain authorization requests.

Regulatory Agency and System Operator are reviewing the rules

“Amnesty” of contracts – 11 GW of generators interested (low market prices adversely affected returns)

New connection process under discussion (auctions for connections being studied along with a more solid scheme of guarantees)

Amount of Authorization Requests (GW)



Conclusion

1

Brazil has experience in building an extensive transmission system that allows it to integrate renewable generation

2

In the country, the regulatory framework of the transmission business has been successful – It demands a constant balance of stronger incentives, stricter rules and solid institutions to secure the enforcement

3

A good and strong regulatory framework combines security to investors while encouraging efficiency

4

Like in the rest of the world, the increase of non dispatchable renewable generation brings more challenges to be overcome for the transmission planning and implementation



Thank you!

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