Planning of electrical transmission in Brazil and HVDC technology as an alternative for an efficient electrical operation

International Seminar of HVDC Electrical Transmission System

Chile

Superintendência de Transmissão de Energia Elétrica

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Santiago, Chile
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Empresa de Pesquisa Energética
Ministério de Minas e Energia

Transmission Planning and HVDC in Brazil

Summary

- EPE – Empresa de Pesquisa Energética
- Itaipu HVDC ± 600 kV system
- An integrated network
- HVDC Madeira ± 600 kV system
- HVDC Belo Monte ± 800 kV system
- HVDC new system possibility
- Transmission Planning 10 years projection

EPE – Empresa de Pesquisa Energética

www.epe.gov.br

Since 2004

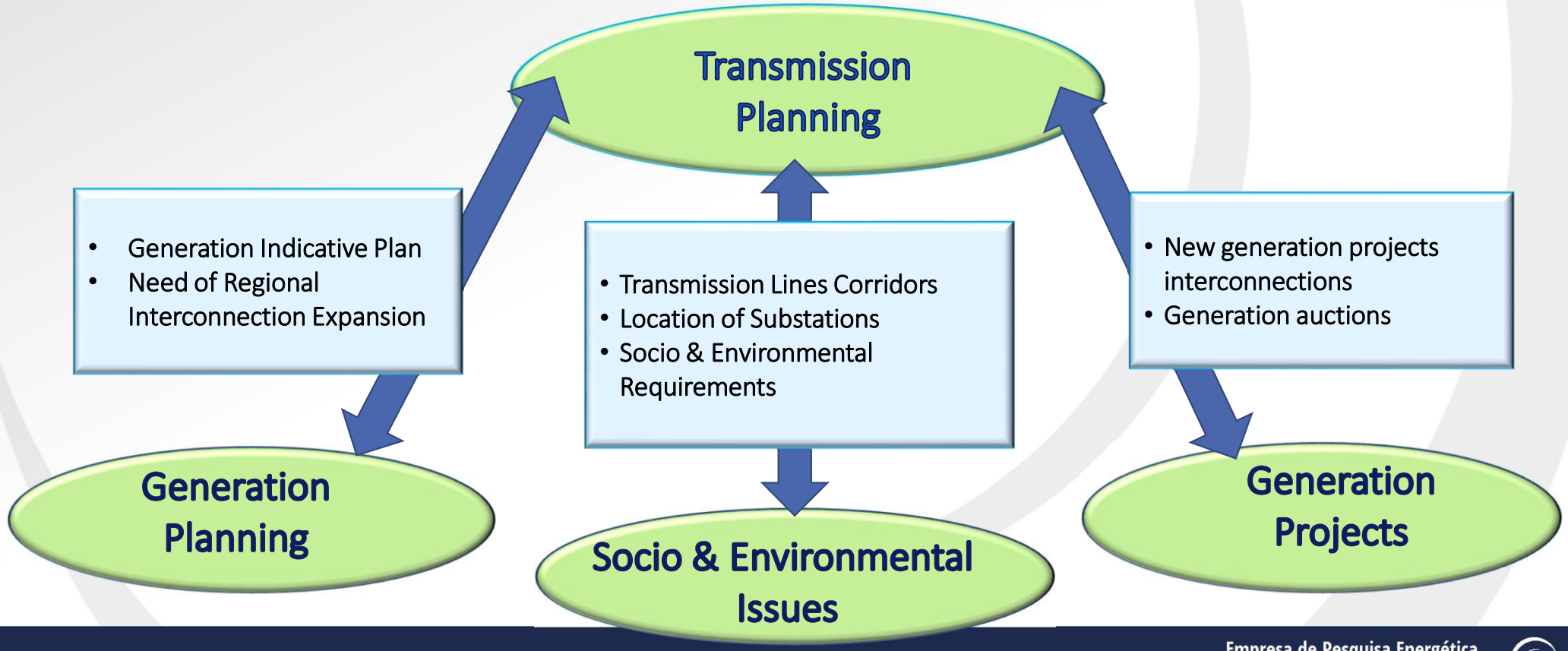
State-owned company linked to the Brazilian Mines and Energy Ministry

We develop integrated energy studies and statistics aiming to subsidise the formulation, deployment and assessment of the national energy policy.

EPE – Empresa de Pesquisa Energética

Transmission Planning Process carried out by EPE

Integrated Planning: Generation, Transmission, Socio & Environmental Aspects



EPE – Empresa de Pesquisa Energética

Types of Studies Before Auction

- Technical, Economic, Social & Environmental Feasibility Studies - R1
  - *Load Flow*
  - *Stability studies*
  - *Preliminary Environmental Assessment*
  - *Economic evaluation*
  - *Short-Circuit analysis*
- Engineering Studies - R2
  - *Electromangetic Transients*
  - *AC and DC Transmission line and equipment preliminary specifications*
  - *Control models for special equipment*
- Social & Environmental Assessment - R3
  - *Referential definition: transmission lines routes and substations locations*
- Technical Compliance with Existing Grid - R4
  - *Protection, Monitoring and Control Requirements Descriptions*
  - *Sharing of existing infrastructure*
- Property and Land Analysis- R5
  - *Land and property costs*

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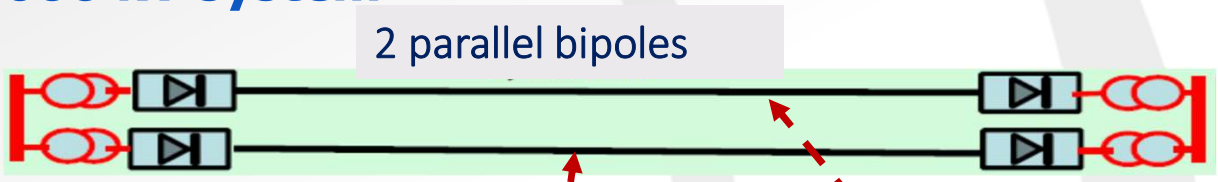
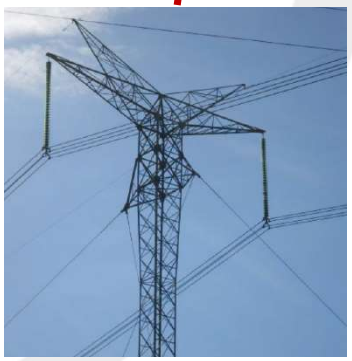
HVDC pioneer project: Itaipu ± 600 kV system



~20 to 30
km apart



Guyed towers

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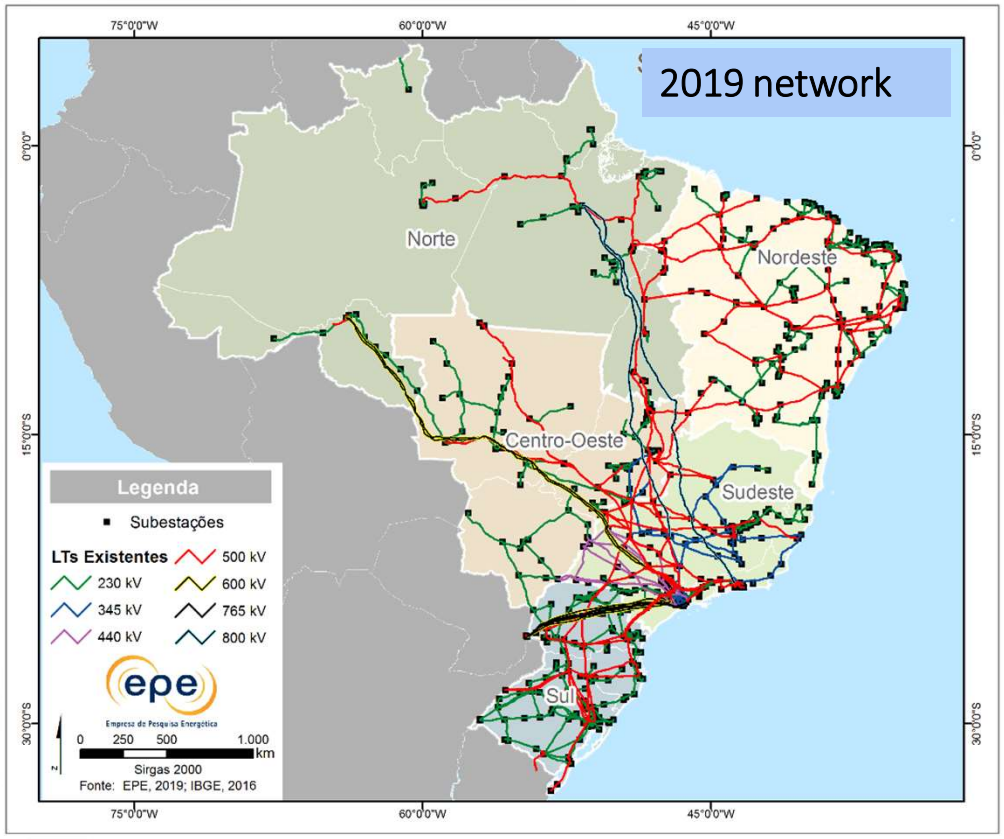
Large expansion and integration: an interconnected network (few exceptions)



meshed and resilient grid

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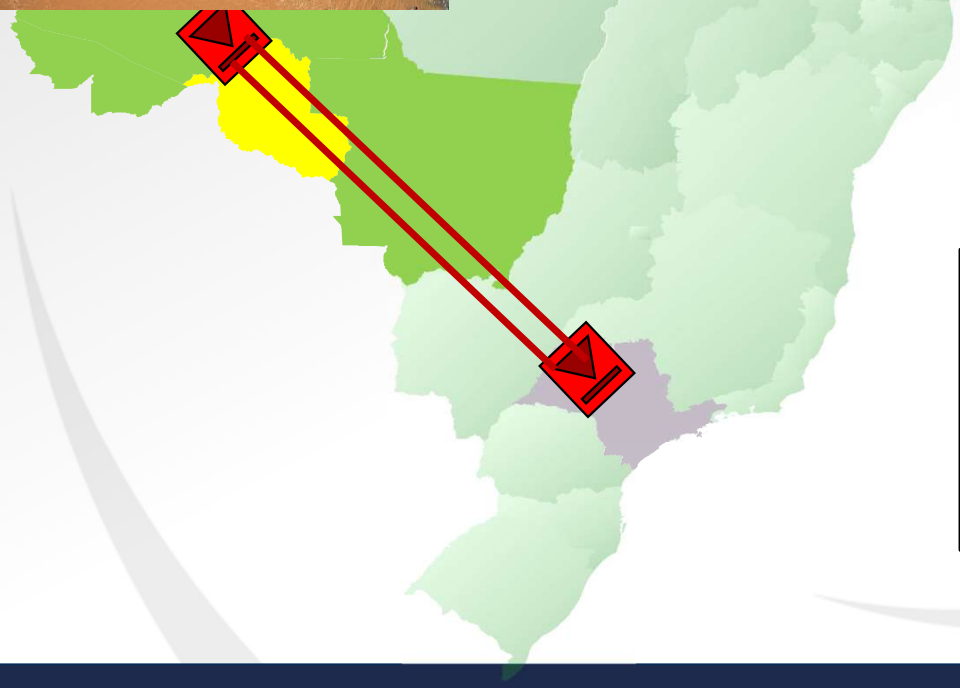
HVDC Madeira 600 kV transmission system



~7,0 GW, main load center at ~2350 km

Alternatives initially selected :

- **DC (2 x 3150 MW bipoles);**
- **Hybrid: DC bipole (3150 MW) + 2 x AC 500 kV parallel lines;**
- **AC: 3 x AC 765 kV parallel lines (further analysis discarded)**

DC and Hybrid alternatives competed in a concession auction (Nov/2008):

- **DC Alternative, the winner with annual revenues smaller (7.15% average) than the established ceiling.**

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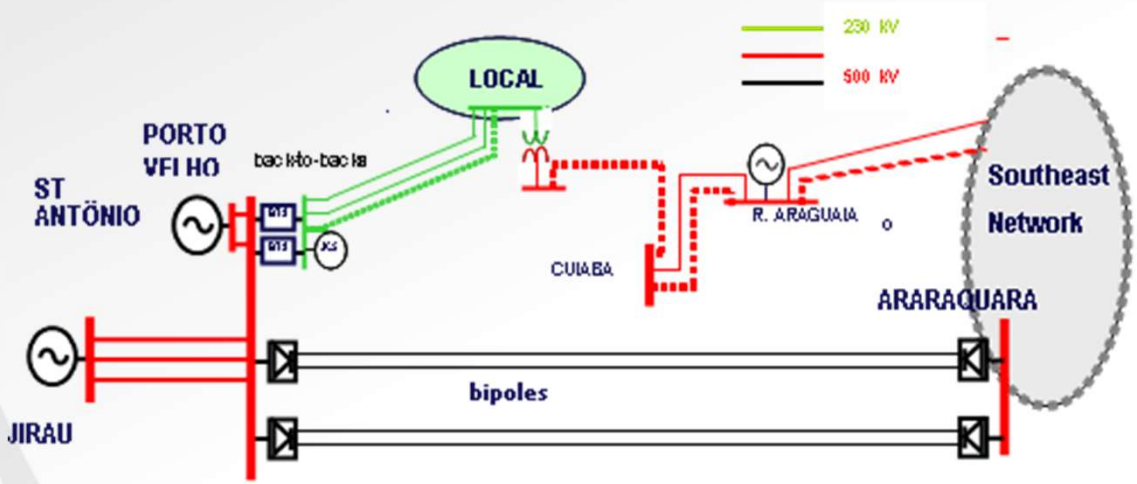
HVDC Madeira transmission system

Two HVDC ± 600 kV bipoles (3,150 MW) and two back-to-back (400 MW) to feed local loads



~2,350 km

Different concessions
Different manufacturers
Back-to back with CCC technology

The longest lines in the world

- **3 projects along the route**
- **Guy type towers**
- **Lines 10 km apart**
- **Each line capable to transmit with two parallel converters**

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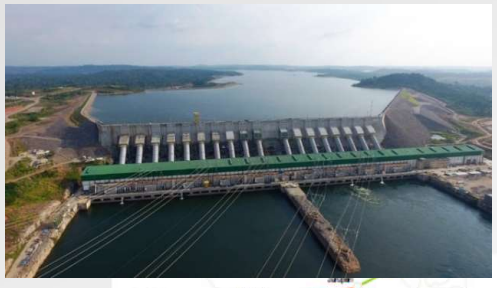
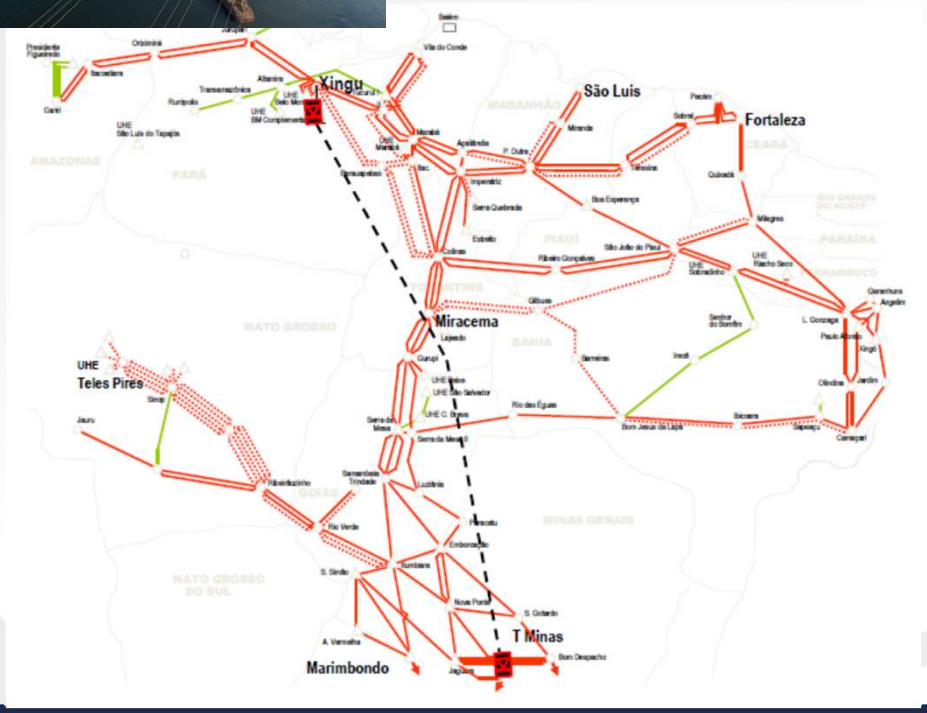
HVDC Belo Monte ± 800 kV system





Constraints and Strategic Decisions

- 8.000 ~ 10.000 MW to be transmitted
- very long distance ~ 2.500 km
- 500 kV AC network, along route
- no need of load integration along route
- an economic and technical comparison between technology alternatives = HVDC

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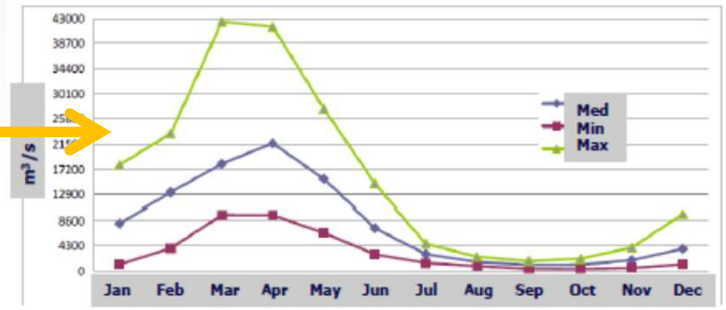
HVDC Belo Monte ± 800 kV system

Reversal transmission

- run-of-river design of Belo Monte
+
- characteristics of the Xingu river



power generated, from 11.000 MW (wet season) to zero (dry months)

+

power demand by the northern part of the grid

- **reversal transmission(South to North)**
- **some generators as synchronous**

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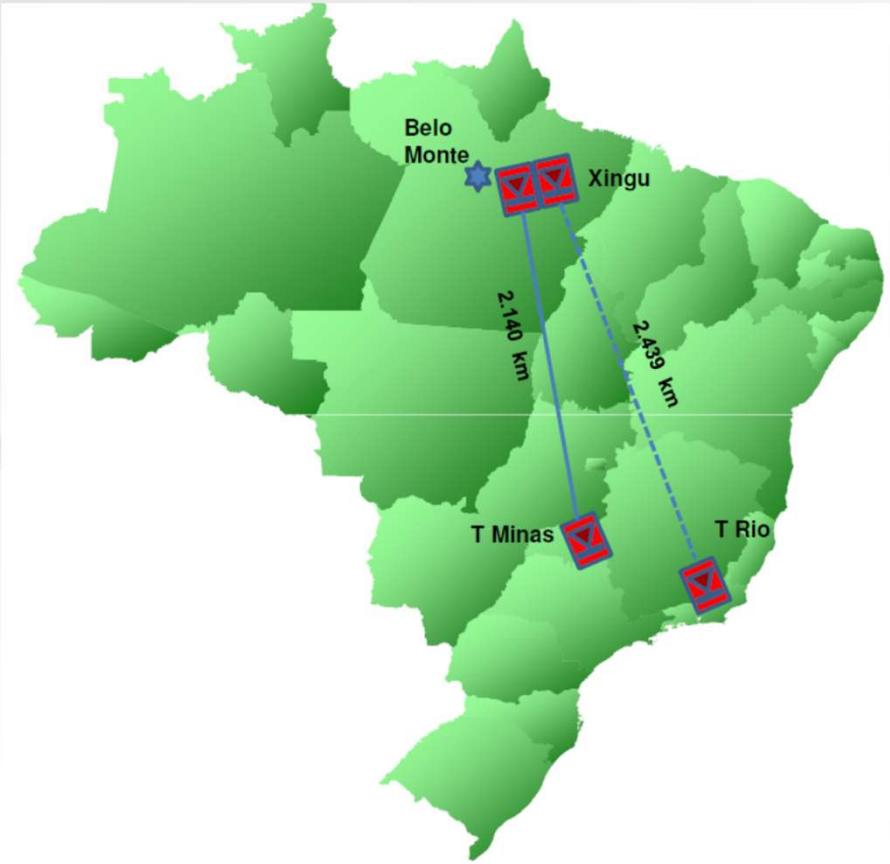
HVDC Belo Monte ± 800 kV system



Planning results

- **2 x 4000 MW bipoles, 800 kV**
- **embedded HVDC system**
- **reversal transmission**
- **two separated power injections in the Southeast region**
- **not imposing a specific number of 12 pulse converter bridges per pole**

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HVDC system new possibility

Motivation (I)

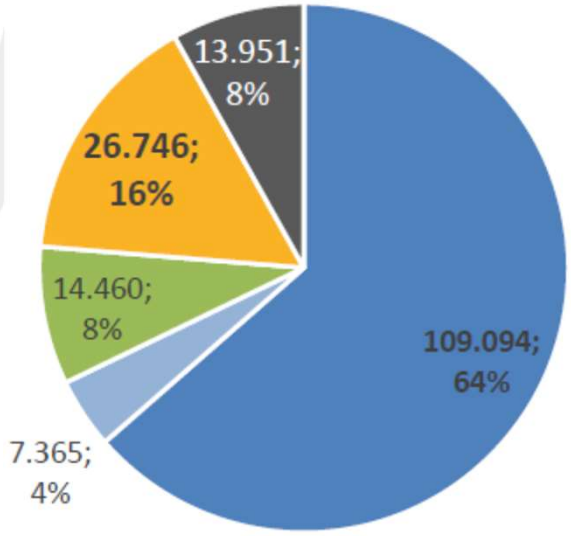
Strong enhancement of variable renewable generation (VRG) mostly in the Northeast region

Actual installed capacity (2020)

Wind + Solar: 18,706 MW (11,2%)
Hydro: 108,495 MW (65,8%)
Total: 165,039 MW

PDE 2030

- Hydros
- Small hydros
- Biomass
- Wind + Solar
- Thermal



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HVDC system new possibility

Motivations II

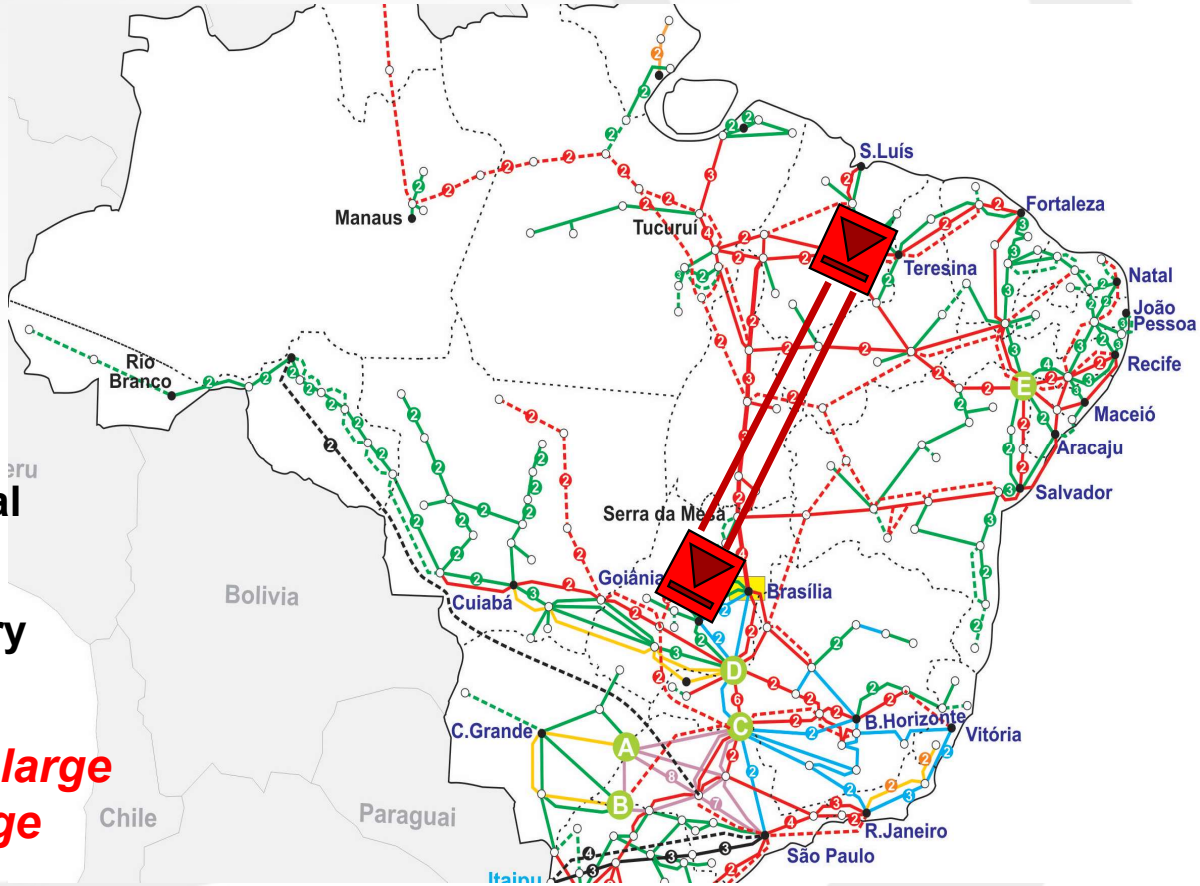
Reinforce the main north-south transmission corridor for national energy security

Improve network controllability

Increase AC system capacity to absorb additional VRG

Potential to reduce thermal generation during dry seasons in the Southeast

Embedded and not associated to a specific large generation project, but to exportation of large concentration of VRG in NE region



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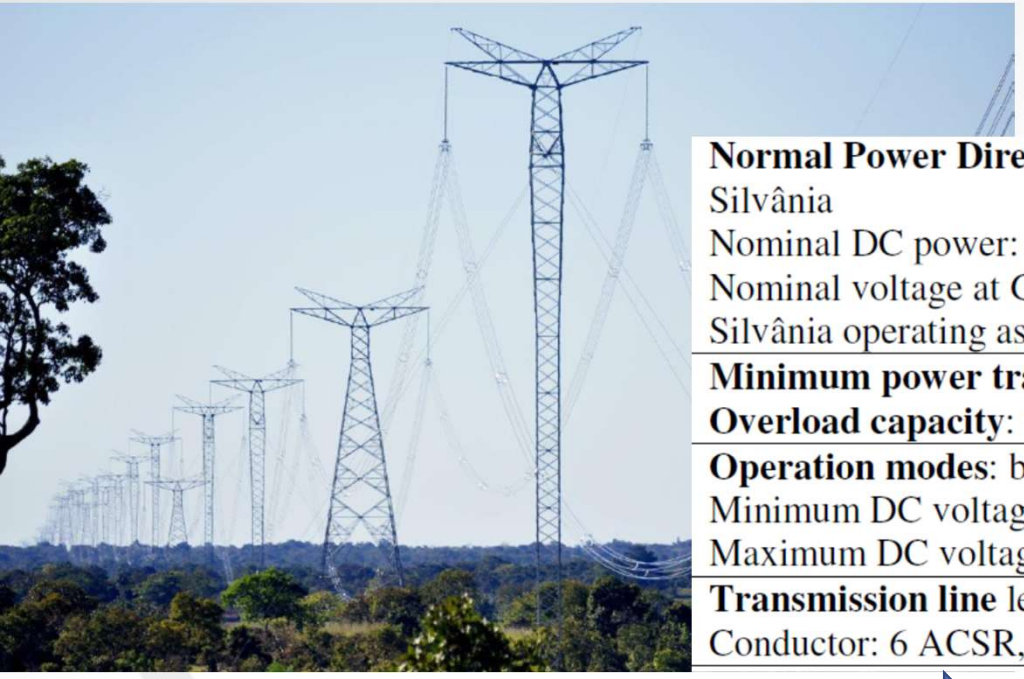
HVDC system new possibility : 800 kV HVDC Graça Aranha - Silvânia

First stage of the planning studies : Report R1



Normal Power Direction: Graça Aranha to Silvânia Nominal DC power: 4,000 MW at Graça Aranha Nominal voltage at Graça Aranha: ± 800 kV Silvânia operating as inverter: 3890 MW	**Reverse Power Direction**: Silvânia to Graça Aranha Nominal DC power: ~3,300 MW at Silvânia Nominal voltage at Silvânia: ± 800 kV
Minimum power transmitted: 10% of nominal power **Overload capacity**: 33% during half hour after pole or bipole lost; 50 % during 5 seconds	
Operation modes: bipolar, monopolar with metallic return, monopolar with ground return. Minimum DC voltage: 0.7 of nominal voltage Maximum DC voltage: 830 kV	
Transmission line length: 1,500 km Conductor: 6 ACSR, 1590 MCM "Lapwing", per pole.	

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Currently in planning review

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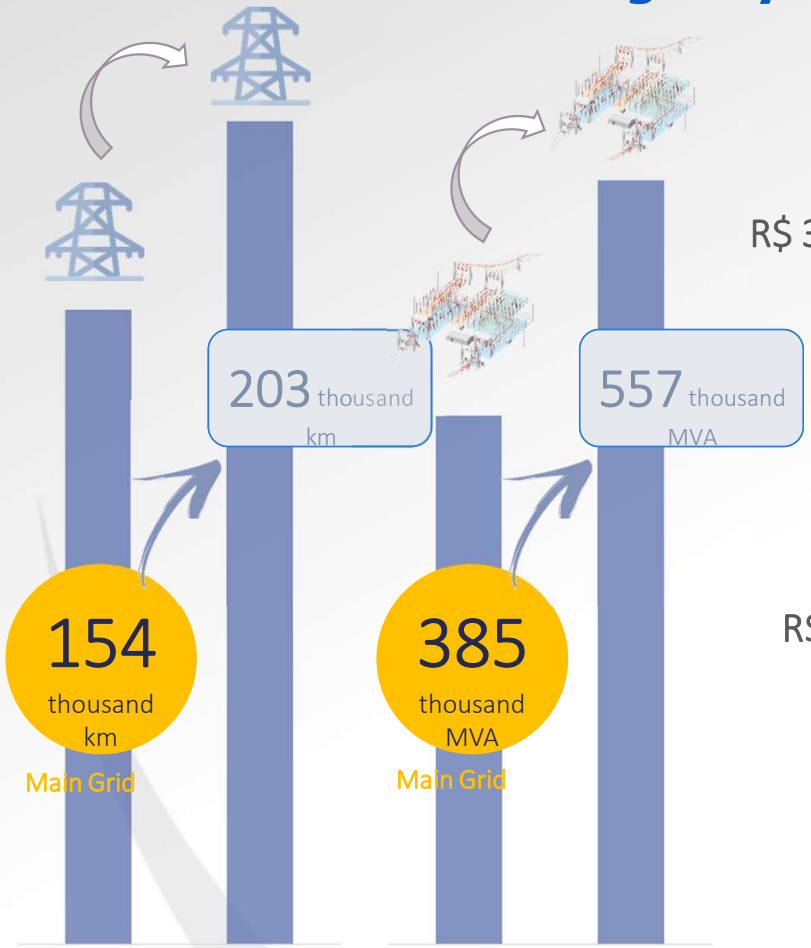
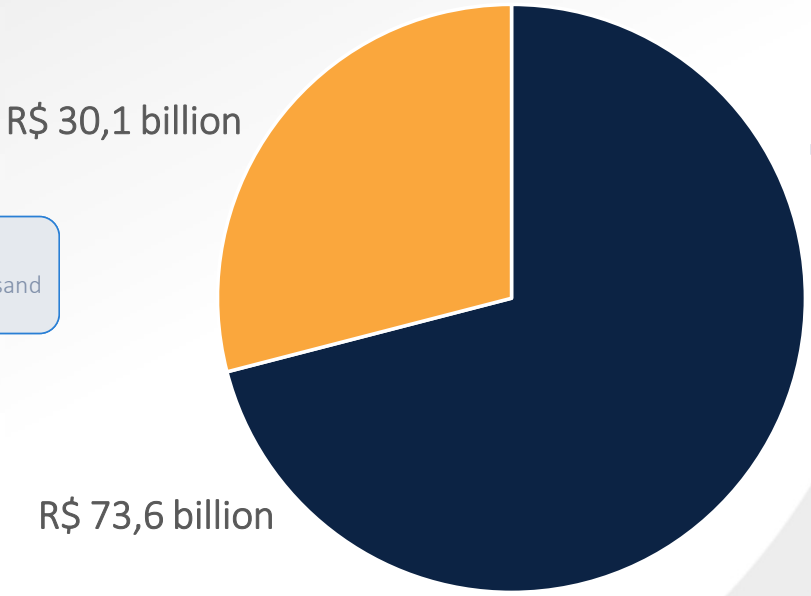
Transmission Planning 10 years projection





Total investment of **R$ 103,7 billion (US$ 24 billion)** until 2029. All of them defined by EPE

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Obrigado!

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