Towards Smart and Flexible Power Systems

Application of Intelligent Systems

Challenges and opportunities in Energy Transition

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Agenda

- Energy Transition
- Renewable Energy Resources
- Research Areas
- Future Trends and Conclusions

Energy Transition

What is Energy Transition ?

Changes on Energy Matrix

The energy transition involves replacing fossil fuels with renewable energy sources, crucial for a sustainable future

Fight Climate Changes

This transition is crucial for significantly reducing carbon emissions and effectively fighting climate change globally.

Energy Security

To promote reliable access to clean and sustainable energy to the society

Motivations for change

Expansion of renewable energy

Reduction of costs related to renewable energy technology.

Climate change challenges

Importance to adopt sustainable energy solutions to face the climate change and protect the natural environment.

Job opportunity

Creation of new jobs opportunity and social inclusion

Global Goals and International treaties

The Paris Agreement

The Paris Agreement aims to limit the global temperature and to reduce the greenhouse gas emission.

CO2 Emission Reduction

The countries are encouraged to implement policies to reduce their emissions, aiming for a more sustainable and low-carbon future.

Global Cooperation

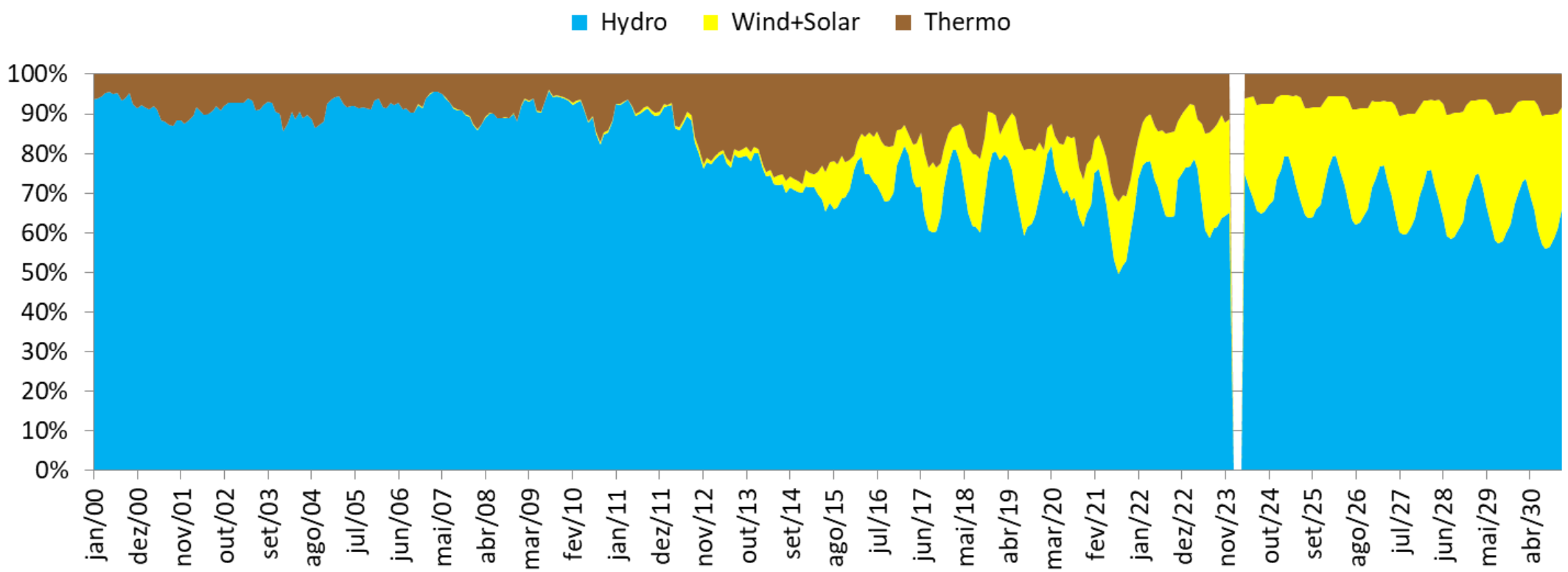
The effectiveness of the energy transition depends on coordinated efforts between countries, promoting international cooperation.

Renewable Energy Resources

Main Renewable Energy Resources in Brazil

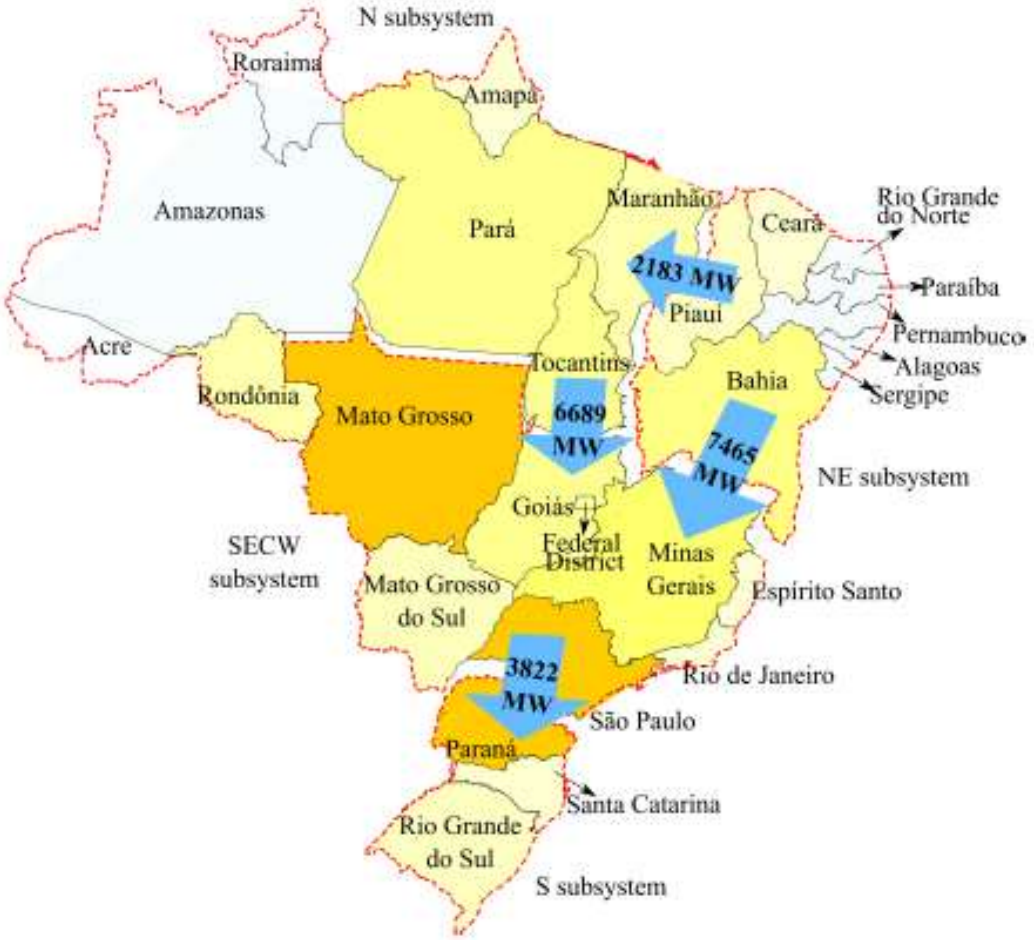
- Solar
- Wind
- Hydro
- Biomass

Raise of Solar and Wind Generation in Brazil



Source: Graph provided by Prof. Erik Rego – PRO-USP

Challenges with Wind and PV



Availability

The variability of the sources imposes difficulties for the efficient coordination

Coordination

Coordination with different sources and strategic energy management is required for the large system operation

Distributed Effect

Renewable Generation exists as a system connected large generators or as distributed generation in the consumer areas.

Technology Advance

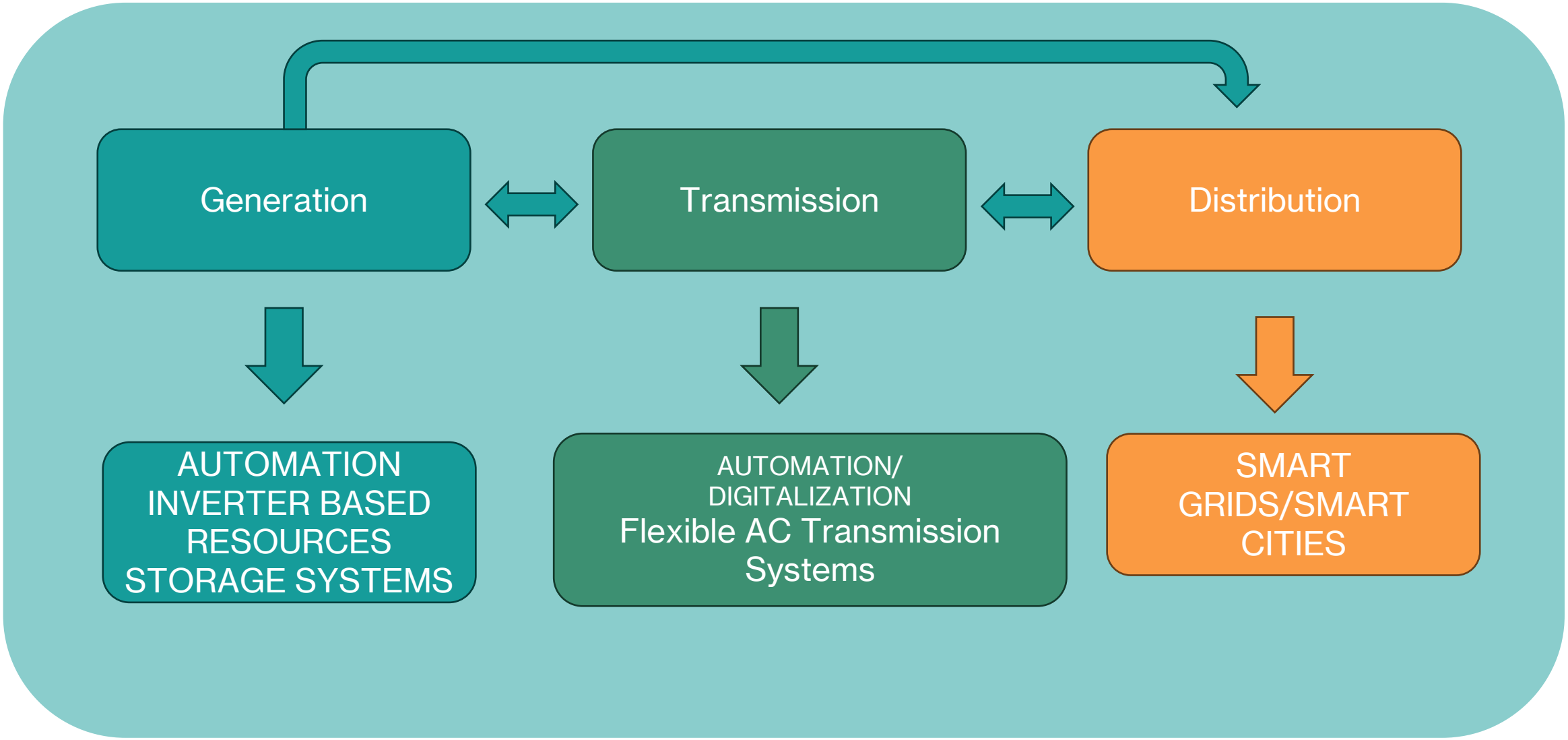
Advances on transmission technology**: FACTS devices, storage systems , computing system.** They will be necessary to achieve a more flexible system.

Regulatory, Political and Economical Challenge

Investment and political support will be needed for the energy transition

Source: Challenges in Increasing Inter-Area Power Exchange in the Brazilian Interconnected Power System (to be presented in the 2025 IEEE PES GM, AUSTIN, TX, USA)

Are the Energy Systems Becoming Smart ?



Research Areas

IEEE PES General Meeting Themes (The largest conference in the area)

2009 – Investment in workforce and innovation for power systems
2011 – The Electrification of Transportation & Grid of the Future
2012 – New Energy Horizons – Opportunities and Challenges
2013 – Shaping the Future Energy Grid
2014 - Charting the Course to a New Energy Future
2015 – Powering Up the Next Generation
2016 - Paving the Way for Grid Modernization
2017 – Energizing a More Secure, Resilient & Adaptable Grid
2018 – Re-Imagining the Electric Grid
2019 – Expect Uncertainty | Prepare to Adapt

- 2020 - Embracing Advanced Technology in Power and Energy Systems for Sustainable Development
- 2021 – Managing energy business during pandemic
- 2022 - Powering a Sustainable Future in a Changing World
- 2023 – Meeting the Energy Needs of a Dynamic World
- 2024 – The New Electric System: Reinventing & Resilience
- 2025 – Achieving Deep Decarbonization

Research Areas

Generation

Transmission

Distribution

- System Analysis
- Development of methods and algorithms
- Application of optimization methods
- Application of intelligent systems
- System operation planning
- System expansion planning

Protection System
Stability Analysis
System Performance
Data Acquisition
Data Analysis
Control Systems
Real-time simulation

Integrated R&D Projects

MITtrans - Mitigate Curtailment of Renewable Generation With Optimal Allocation of Energy Resources and FACTS in Brazilian Power System

FlexHostCap - Flexible Solutions to increase the hosting capacity of distributed energy resources

FaultAIFinder - Fault location of onshore wind farm collector network based on artificial intelligence and drone supervision

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Innova Power

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Power Systems Innovation Hub

Generation Curtailment

Generation Curtailment represents a series of procedures to reduce or interrupt the Generation (Hydro, thermal, wind or solar).

- Exceeding energy offer
- Power transfer limitation

Not Generation Curtailment

- Protection actuation
- Maintenance

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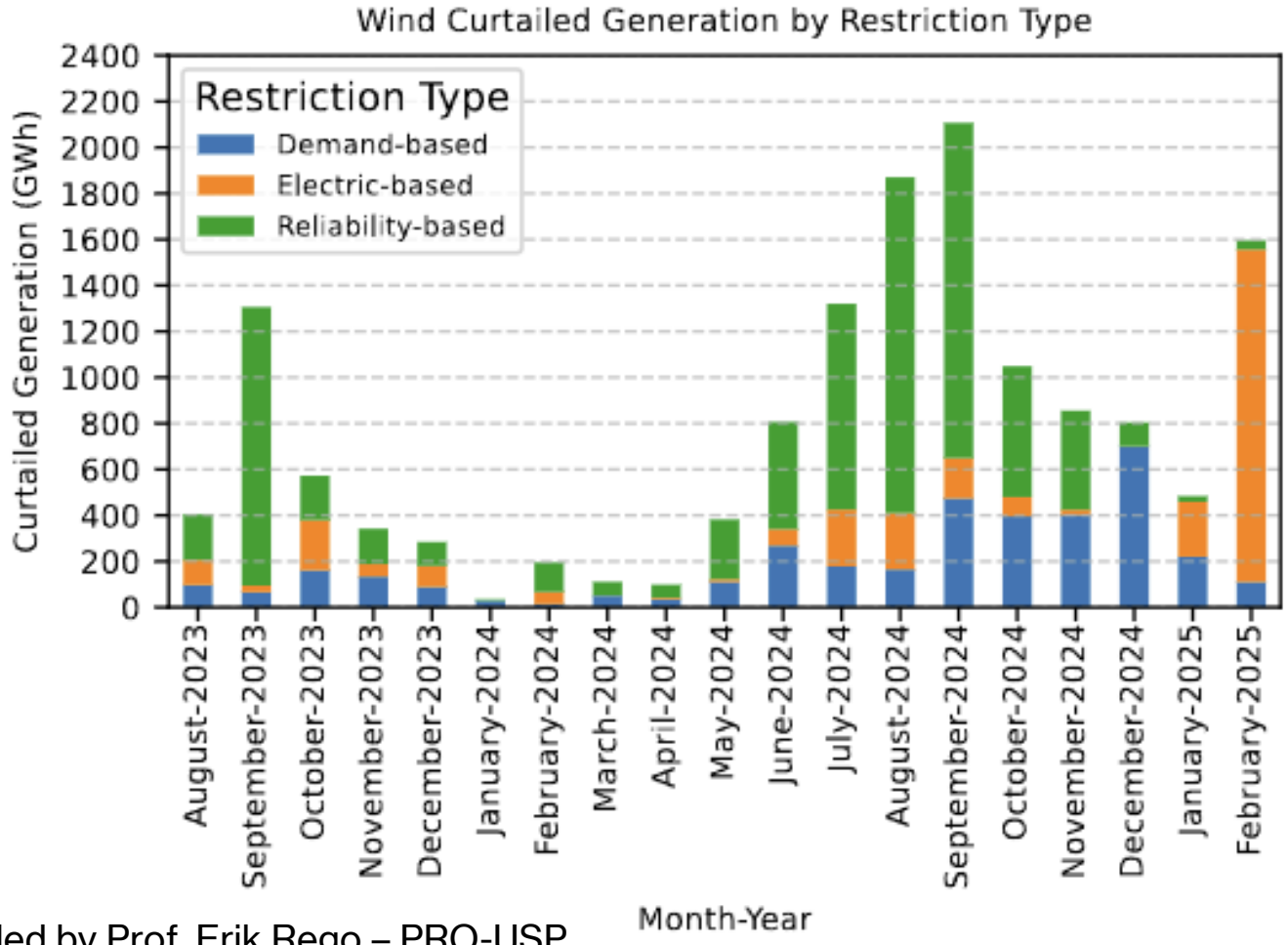
Wind Curtailed Generation



Source: Graph provided by Prof. Erik Rego – PRO-USP

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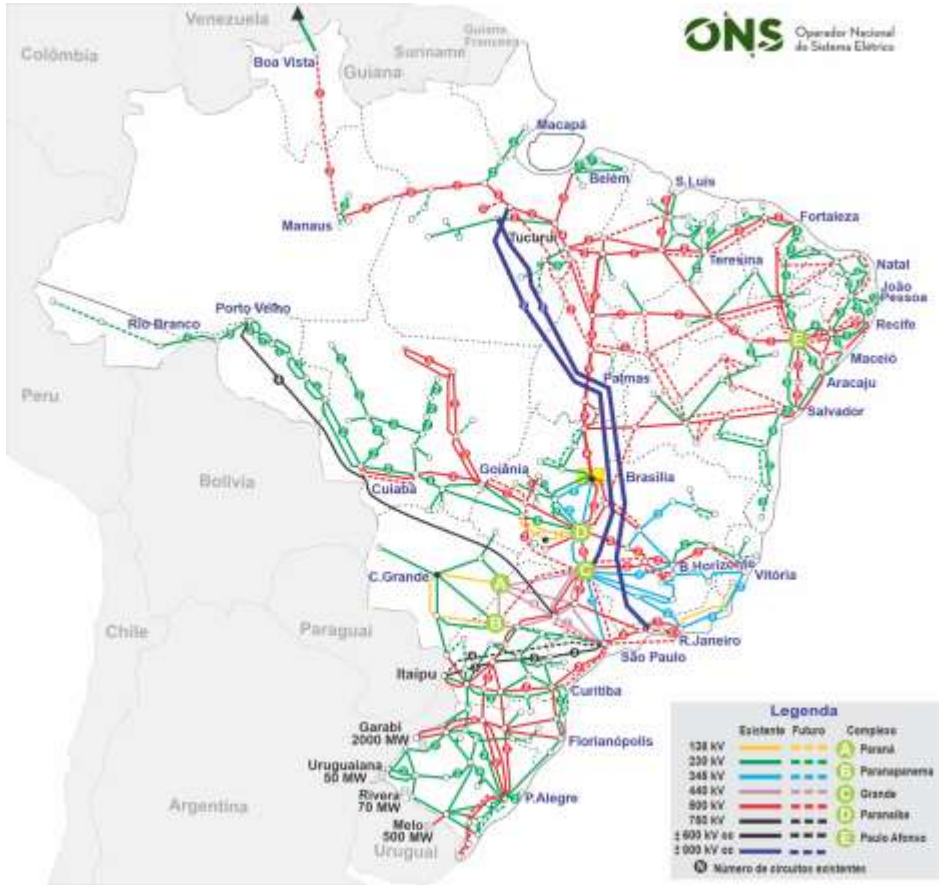
Project objectives

To identify current system limitations and propose new operational and investment strategies to maximize the insertion of renewable Generation and maximize the application of FACTS devices and storage systems.



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Wind Generation and Curtailment

- Hinders the efficient operation according to the current wind conditions
- Storage might be necessary
- Economic losses
- Impacts the clean energy transition

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Future Trends and Conclusions

Future Trends

Increase of Renewables

The significant increase of renewable sources, mostly wind and photovoltaic generation

Reduction of Carbon Emission

A consequence of a change in the energy matrix towards renewable is the reduction of carbon emissions, which contributes with the environment.

Technology Advance

The technology will have to provide a more flexible system with a wider look at the Generation, Transmission, and Distribution Area (storage system, new sources, transmission technology, Intelligent systems, etc)

Economic Impacts and Regulatory Challenges

Regulatory Challenges

The transition might require regulation changes, which impacts all sectors and demands political engagement among the actors to create an environment that incentivizes innovation and economic adaptation.

Economic Challenges

Changes in the energy matrix will affect traditional sectors and create new opportunities (businesses and jobs)

Conclusions and Suggestions for the Success of Energy Transition

Opportunity

The energy transition is an opportunity for developing a sustainable infrastructure with economic and technology advance.

Collaboration / Education

It is necessary to promote collaboration among different sectors and areas of the society (Population, industry, Academia, etc) and promote qualitative education in this area

Development of Green Energy Technology

Investing in research and development of green technology and ways to improve the system operation flexibility

Information technology

Application of intelligent systems for data analysis, automation, control in an integrated environment to perceive the system as whole lead to the smart use of the resources