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HETEROGENEOUS REAL-TIME SIMULATION PLATFORM - THE ONS EXPERIENCE

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Presentation Topics

- General data of Brazilian Electric Power Transmission and Generation
- The ONS and its Real-Time Simulator Facility
- The Real-Time Coperative Simulation – Motivation and Requirements
- The Heterogeneous Simulation Platform – Advantages and Dificulties
- Remote Coperative Simulation – Feasability ?
- Conclusions

The Brazilian Power Sector - Institutional Structure

MME
Ministry of Mines and Energy

Brazilian government ministry - Implements sectorial policies (electricity, oil, gas, mining)

EPE
Energy Planning Company

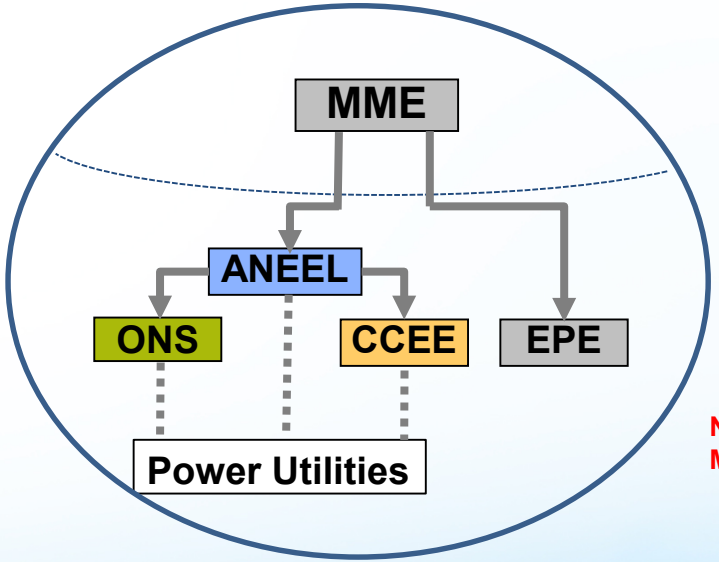
Public company – Electric system expansion planning

ANEEL
Electric Energy National Agency

Government agency - Regulation, mediating and control

CCEE
Electric Power Trading Chamber

Non-profit civil association - Energy Trading Accounting

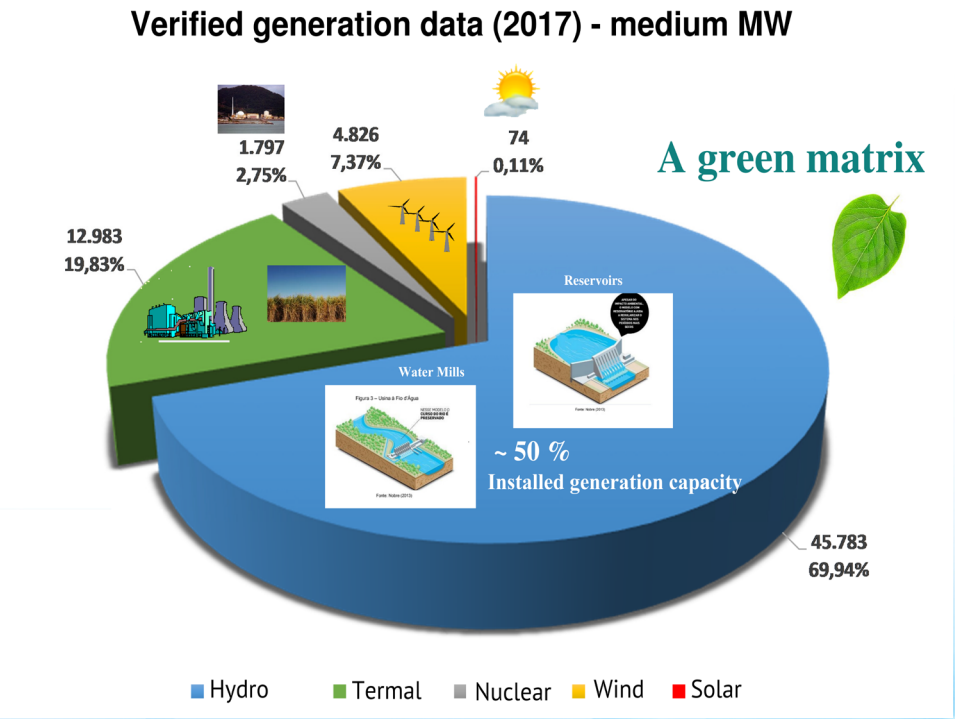


Generation, Transmission and Distribution Companies, Energy Traders, Free Consumers, Energy Importers and Exporters

ONS
Electric System National Operator

Non-profit private organization
Main Grid system operation

Brazilian Electric Power Generation Data - Planning of Expansion



Source	Power (GW)		Increase	
	2016	2026	(GW)	%
Hydro	96,7	110,5	13,8	14,3
Small hydro + Biomass	18,7	25,1	6,4	34,2
Wind	10,0	28,5	18,5	185,0
Photovoltaic	0,0	9,7	9,7	-
Nuclear	2,0	3,4	1,4	71,0
Fossil	21,0	35,4	14,4	68,6
Renewable	118,4	166,8	48,4	40,9
Not Renewable	22,0	38,8	16,8	76,4
Total	140,4	205,6	65,2	46,4

- It is a green matrix: About 84% of the installed capacity is renewable.
- 74% of the planned expansion for electric power generation is based upon renewable sources (29% Hydro, 38% Wind, 20% Photovoltaic and 13% Others).

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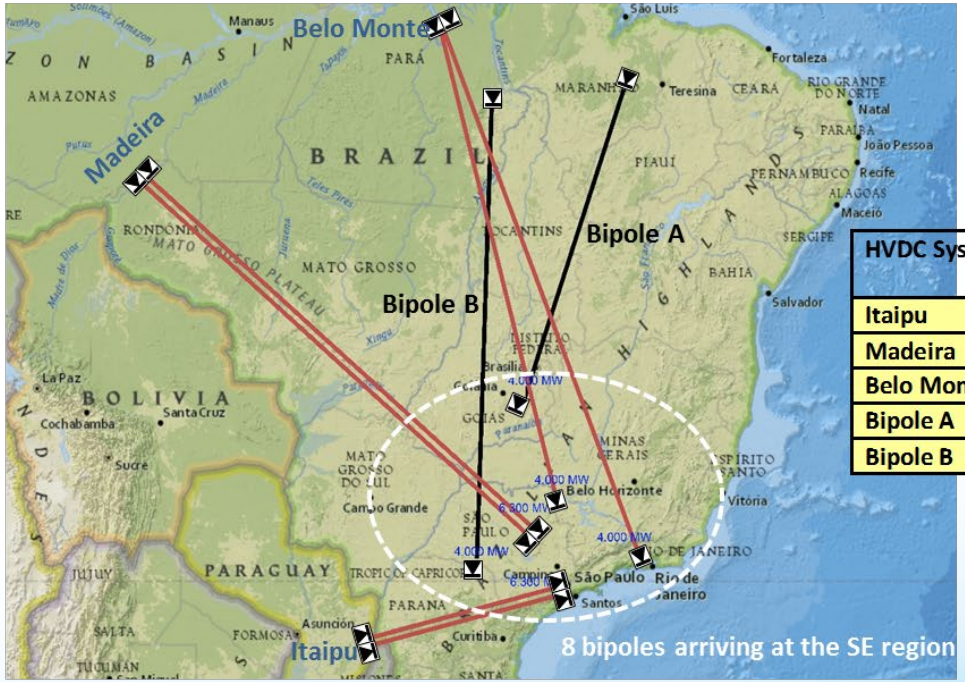
Brazilian Electric Power Transmission – HVDC links



- Planning studies identify capacity to generate 17,508 MW in three hydrographic basins in the North region (Tapajós, Tocantins and Juruena rivers).

HVDC System	Voltage (KV)	Power (MW)	DC line length (Km)	Initial operation
Itaipu	±600	2x3150	800	1984, 1987
Madeira	±600	2x3150	2375	2013, 2014
Belo Monte	±800	2x4000	2092, 2439	2017, 2019
Bipole A	±800	4000	1941	to be auctioned
Bipole B	±800	4000	1460	to be auctioned

Bipole A – Network expansion for power transmission from from Hydro sources in the North.

Bipole B - Network expansion for power transmission from renewable sources (wind and solar) in the Northeast and Central West.

Note - Due to environmental issues, the bidding process of the Tapajós generation and transmission system is undefined.

ONS Real-Time Simulator Facility (SSCC)

- Main supported activities

- The commissioning tests related with the joint operation of two Bipoles from different manufactures. Master Control adjustment and tunning;
- Analysis of the real plant HVDC controller misoperation due to AC system fault events or as result of power equipment switching;
- Support for multi-infeed studies including the most precise HVDC controllers representation.

- Some challenges

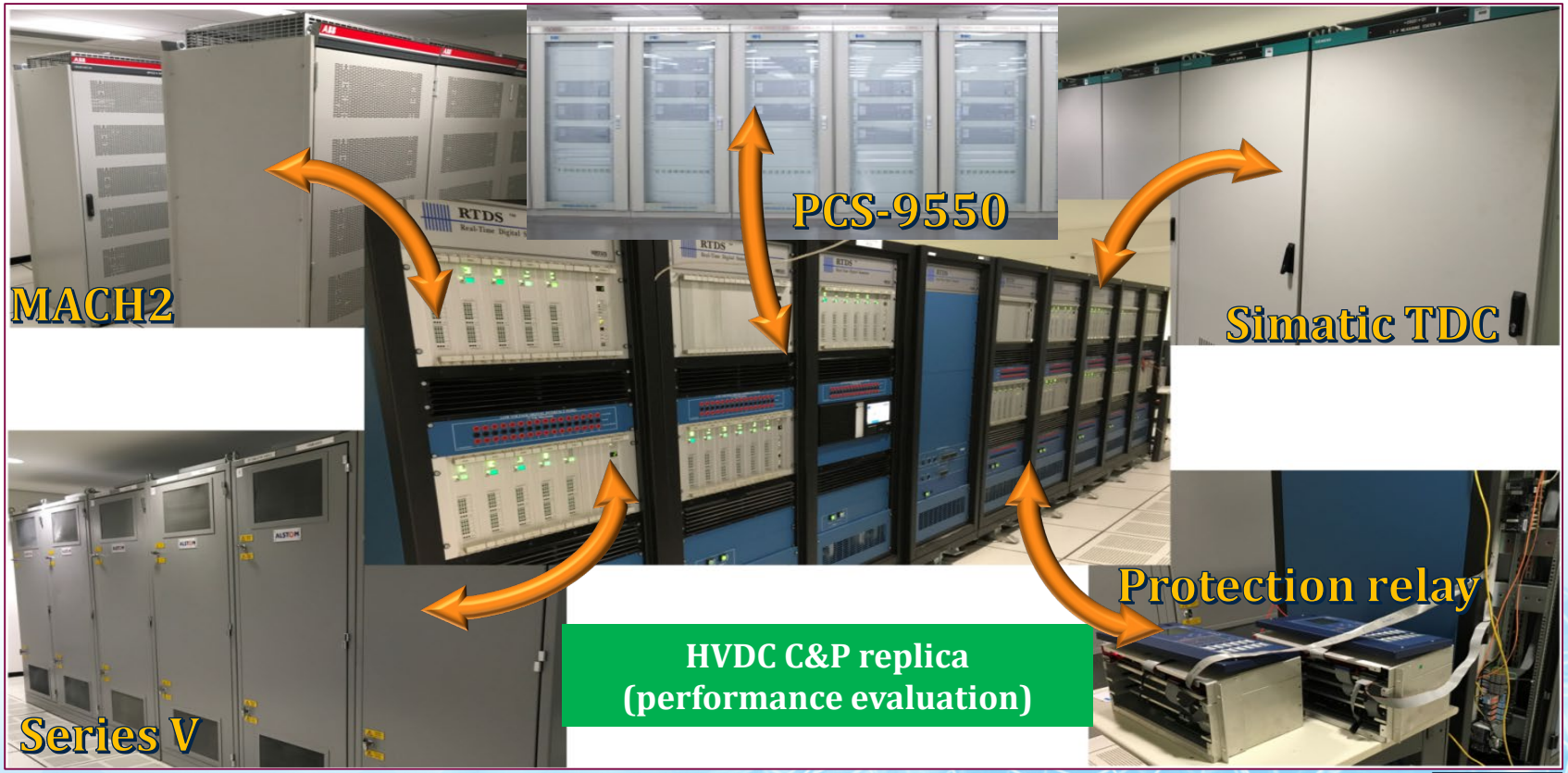
- Keeping of reliability and availability of C&P replicas along of real plant operating time: contract of corrective maintenance and support with the suppliers;
- Familiarize the SSCC crew with the different hardware and software platforms for effect of: fault diagnosis, predictive maintenance, monitoring of internal signals of C&P logic;
- Planning of the expansion and updating of the real-time simulation equipment in aiming to offer technical support to other areas of the ONS.

ONS Real-Time Simulator Facility (SSCC)

ONS Real-Time Simulator Facility – Power System Simulator			
Platform	**Processor & Clock**	**Single phase node limit**	**Number of racks/chassis**
Rack with 05 GPC card	**02 CPUs 1,0 GHz per card**	**72**	**15**
Rack with 5 PB5 card	**02 CPUs 1,7 GHz per card**	**2x90**	
Chassis NovaCor	**01 CPU with 10 cores 3,5 GHz**	**2x300**	**01**
Chassis OP5700 *	**02 CPUs with 08 cores 3,2 GHz**	**16x90**	**01**

ONS Real-Time Simulator Facility – HVDC C&P replicas						
Supplier	**Generation**	**3rd part components**	**Cubicle set ***	**Cubicle Quantity**	**Supervisory System**	**Graphical Engineering Tool**
ABB	MACH2	Communication interface, Industrial computer	Bipole and Back-to-Back C&P logic, Master Control	10	MACH HMI	Hidraw Visual Studio
GE/ALSTOM	SERIES V (VME chassis)	Industrial computer	Bipole C&P logic	06	SAGE	Hand code
SIEMENS	SIMATIC TDC (VME chassis)	TFR	Bipole C&P logic	06	SIMATIC-WinCC	CFC – Continuous Function Chart
NR EC	PCS-9550	?	Bipole C&P logic, Master Control	05	PCS-9550 HMI	Accel Visual suite

ONS Real-Time Simulator Facility (SSCC)



Real-time Coperative Simulation – Motivation

- Initially, the most favorable cost of the Opal-RT platform versus RTDS hardware was the main motivator. Subsequently (second quarter of 2017), the introduction of current multiprocessed platform by the latter company equalized the cost ratio for a similar configuration.

- On evaluation of the co-simulation interface performance some advantages, related with adoption of the commercial hardware with largest application spectrum, were observed.

a) Codification of user's model by visual type interface without hand coding;

b) Modification of component's parameters during runtime without interruption of real-time simulation (recompiling and reloading of executable code);

c) Any Intel based host computer can perform "off-line" debugging of the user's model fully compatible with the "real-time" target computer realization.

Real-time Coperative Simulation - Main requirements for local connection

- Availability of network solution interface for including of electrical component models coded by the user;
- Adoption of a suitable hardware interface (easy to program and update) for data transfer between the simulators;
- Reliable synchronization between the simulators for effect of simultaneous subsystems solution.

Advantages of a heterogeneous real-time simulation environment

- More flexibility for using of various simulation suites with its own visual programming interfaces and specialized libraries: Matlab-Simulink (SimPowerSystems), EMTP-RV (data base conversion);
- Provides the essential infrastructure for performance evaluating of interfaces proposed to support remote co-simulation;
- Alternative use of simulation hardware for "off-line" simulation of large power system with several controllers taking the advantage of multi-processor Intel platform (industry standard tools PSCAD-EMTDC, EMTP-RV, e.g.);
- Provides an alternative to a unique supplier when evaluating commercial proposals for purposes of updating, expanding and improving the real-time simulator.

Some difficulties to overcome

- Co-simulation requires operation under two distinct user interfaces: event scheduling, visualization of results, initial condition adjustment and model initialization, etc.;
- In order to speed-up or even to assure if the steady-state conditions were reached, the user has to set adjustment of initial conditions. The start-up of the full simulation is not simultaneous on both environments what force user to adopt some way of circumventing the initial discontinuity;
- If dynamics of power generation is involved on both parts of the simulated network it will be necessary to synchronize that parts before connecting their interface.

Other possibilities that can be explored

- Modeling and simulation of the network subsystems under different time steps and/or solvers (solution algorithms) coperatively on both simulators;
- Integration of the electromechanical transient simulation tool (ORGANON), adopted for supporting of Brazilian interconnected system – SIN real time operation, as an alternative to dynamic equivalents representation;
- Evaluation of the developed interface for supporting local co-simulation with other real-time simulation centers placed in Rio de Janeiro downtown (CEPEL and Furnas laboratories) with mutual benefits to those involved.

Remote Co-simulation – Advanced Application

- Integration of simulation facilities geographically nearby

ONS – SSCC facility

7,5 Km

FURNAS – SSE Lab

12 Km

CEPEL - LabPMU

17 Km

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Conclusions

- The real-time simulation equipment update plan should consider different technical and commercial requirements associated with the current and future application of ONS's SSCC;
- Among these requirements, the following ones can be considered of greater importance for evaluating of cost-benefit ratio for different platforms: update cycle, flexibility of use and integration with off-line simulation tools;
- The enhancement of a software interface based on a mathematical model of transmission line enables the coperative utilization of Opal-RT and RTDS simulators. As a consequence, the SSCC ONS installation can adopt a heterogeneous simulation environment with the advantage of the combined use of two different real-time platforms in their best characteristics;
- A possible evolution of this initiative opens the perspective of integrating this installation with other nearby and remote simulation centers within Brazil.

THANK YOU

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