Paris Session 2022

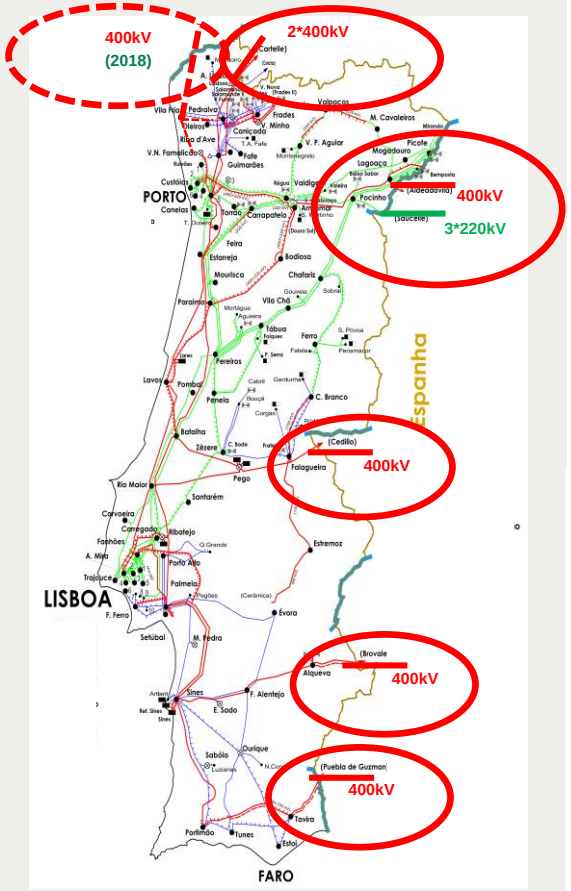
Long-term Operational Reserves Evaluation of Multi-Area Systems – Portuguese Case Study

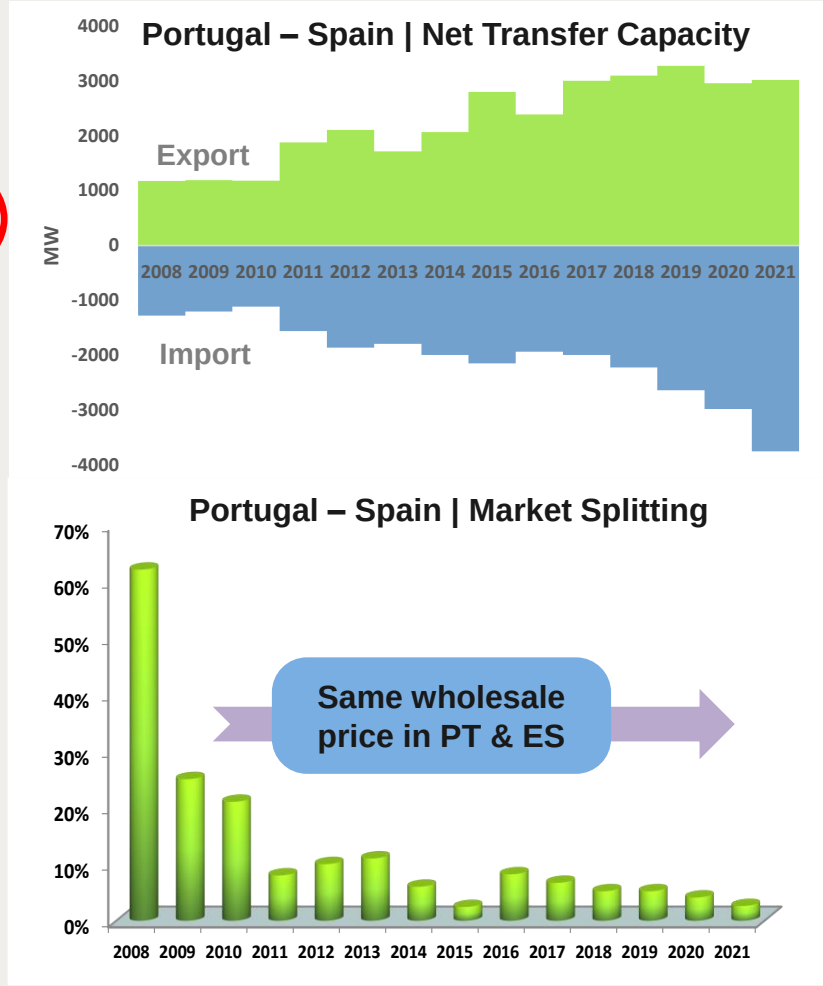
SC C1 / PS3 / Q 3.1.2

Modern power system planning should strive to meet adequacy and stability throughout interconnected networks. How can market rules and operational procedures be adapted to increase interaction between neighbouring utilities/jurisdictions to enhance dispatch rules and balancing of both capacity deficit areas and capacity surplus areas?

Nuno Martins - Portugal

Interconnection role in adequacy and stability





Source: REN

Interconnections increase Security of Supply and Market Integration and contribute to avoiding energy spillage (export energy to neighbour systems)

Interconnection role in adequacy and stability

PS-MORA® simulation model

PS-MORA® simulation model
(Innovative methodology for Adequacy assessment)

Development Team

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PS-MORA® is a registered trade mark of REN

Classical Methodology:
Is the total installed capacity enough to meet the demand in each hour?

PS-MORA model:
Is the operating reserve available every hour enough to balance the forecast errors of load, solar and wind power output and settle the outages that can occur at that hour?

Group Discussion Me

PS-MORA main characteristics

- Probabilistic simulation model (chronological sequential Monte Carlo) of electric systems, to quantify the long-term adequacy of static reserve with **detailed management of the operational reserve**
- Simulation horizon: annual
- Time resolution: hourly, based on weekly merit orders (of VALORAGUA Model)
- Hydrology treated stochastically: energy-limited representation for hydro capacity usage considering 40 years hydrological series of storage volumes for each reservoir (VALORAGUA Model)
- Network: model for internal transmission network and interconnection circuits
- Market rules: different policies for energy and operational reserve exchange between different bidding zones/control areas
- Main results: Security of supply probabilistic indicators, Static and Operational Loss of Load Expectation (LOLE) and Expected Energy Not Supply (EENS). Renewable energy spillage risk during base load periods. Energy generation mix. Total variable cost of electric system. Market prices.

Study's main goal

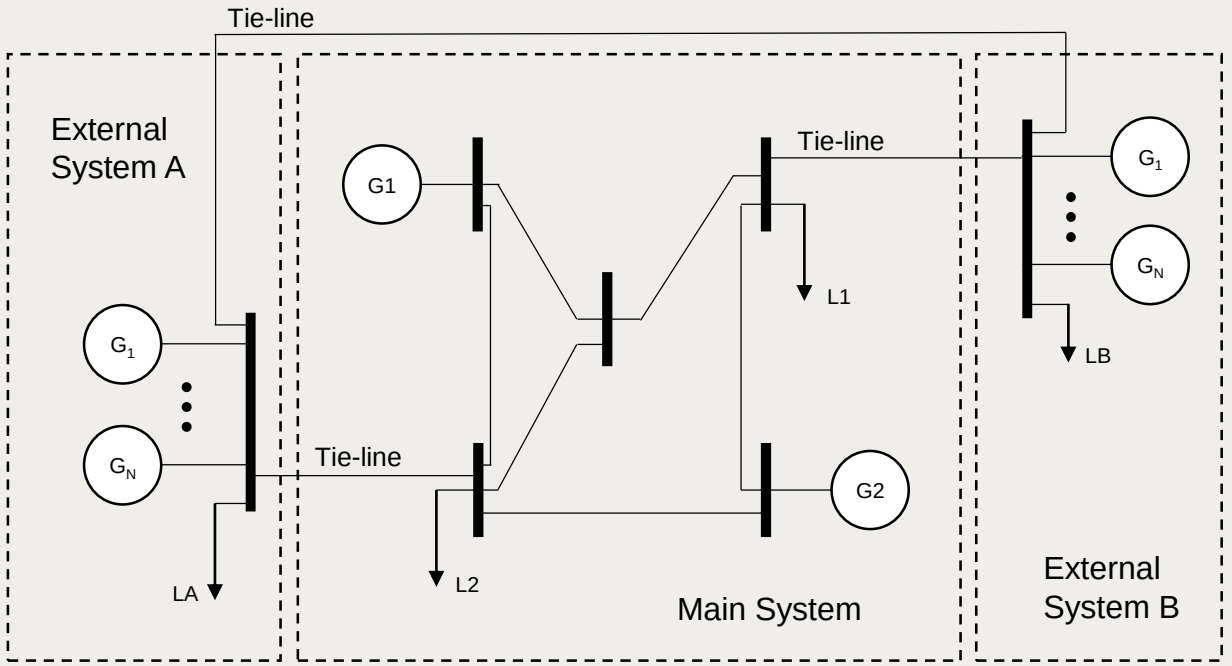
Point out the impacts of considering interconnected systems and the uncertainty related to demand, variable RES generation, and forced outages in generating units and interconnections, in adequacy assessment (static and operational reserve analysis)

Interconnection role in adequacy and stability

Evaluating market rules and operational procedures

Simulation of interconnected generation systems

- Different options for market rules and policies (energy and reserves – FCR & FRR) can be evaluated by tools such as PS-MORA® taking into account different sources of uncertainty (e.g. RES production, load, and forced outages) and physical constraints that might limit their activation & deployment (e.g. primary energy resource limitations)
- The evaluation requires enough flexibility and detail to consider different configurations of the interconnected system and to calculate as accurately as possible the active power flows in tie-lines and, if required, in circuits of an area of interest
  - Challenges:
    - Computation of NTCs & flow sensitivities in the interconnections when the full network model cannot be used or is not available
    - Joint operation of AC and DC interconnections



Multi-Systems with Transmission Network

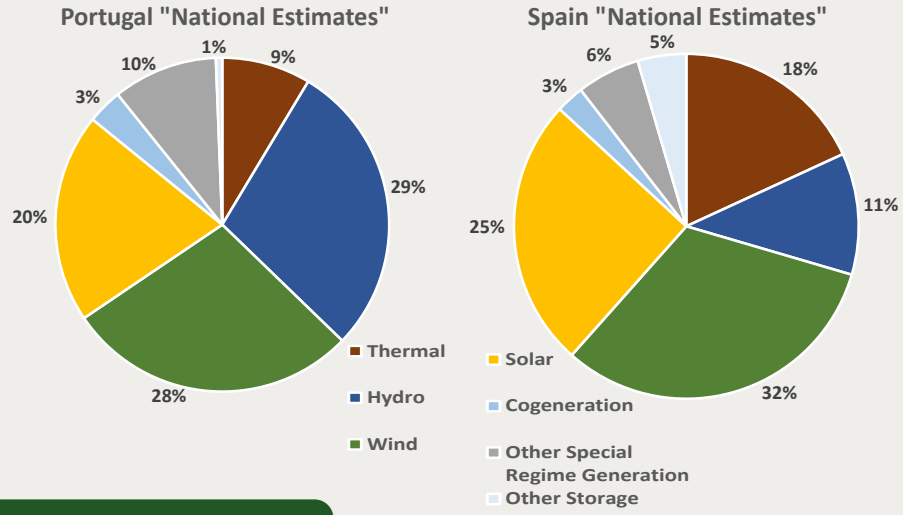
FCR – Frequency Containment Reserve
FRR – Frequency Restoration Reserve

Interconnection role in adequacy and stability

- Adequacy assessment of 2030 configurations
- Focused on performance of the Portuguese electric system considering different NTC constraints between Portugal and Spain and Spain and France
- The NTC between Portugal and Spain is 3500 MW (Portugal exporting to Spain) and 4200 MW (Spain exporting to Portugal)
- French generation system was simulated in a simplified way by considering a single generator and load, with net capacity equal to the NTC (5100 MW)
- 1st scenario: reference configuration for both systems, designated by "National Estimates", reflects National Energy and Climate Plans (NECP) for 2030
- 2nd scenario: for Portugal "Conservative Estimates", used to capture the impacts of possible delays in commissioning new wind and solar projects and in decommissioning cogeneration units while considering a higher peak load

Power System	Portugal "*National Estimates*" [15]	Portugal "*Conservative Estimates*"	Spain "*National Estimates*" [16]
Thermal (GW)	2.8	2.8	27.5
Hydro (GW)	9.3	9.3	17.3
Wind (GW)	9.2	7.4	48.6
Solar (GW)*	6.6	3.6	38.4
Cogeneration (GW)	1.1	1.0	4.0
Other Special Regime Generation (GW)	3.3	3.3	9.0
Other Storage (GW)	0.2	0.2	6.9
Total Installed Capacity (GW)	**32.5**	**27.7**	**151.7**
Demand (TWh)	56.3	56.0	263.0
Peak load (GW)	9.2	10.1	47.8

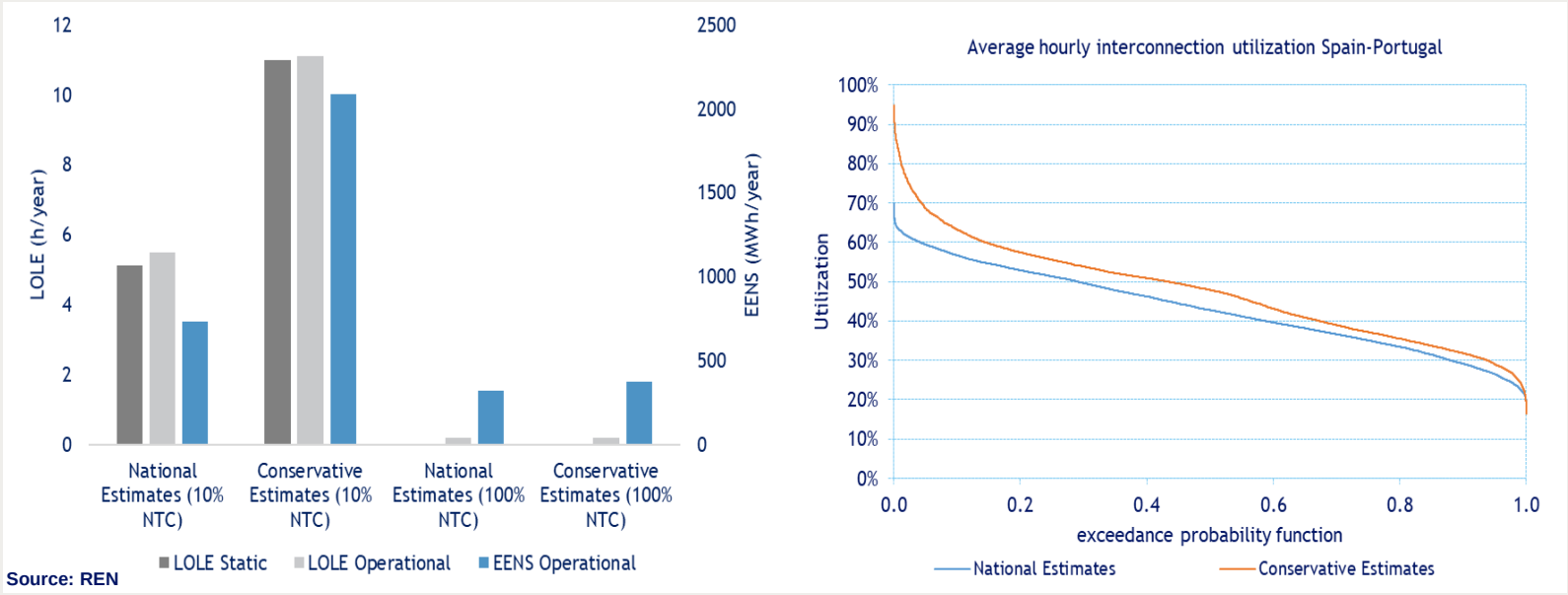
*Distributed capacity not included. The total solar installed capacity in Portugal is 9.2 GW for "National Estimates" and 6.2 GW for "Conservative Estimates"



Remaining interconnection capacity used to mitigate imbalances in the Portuguese electric system and to avoid curtailment of surplus RES

Interconnection role in adequacy and stability

2030 Main Results



Source: REN

Portugal and Spain interconnections, 2 simulation options:

(a) limited support from Spain, 10% of the NTC between SP-PT [1] (isolated system)

(b) both Iberian systems interconnected at full 100% NTC [2]

1) Total nuclear and RES generation in Spain plus the interconnection with Morocco is less than its hourly demand, and 100% in the remaining hours
2) including the 100% NTC corresponding to the virtual node representing the French electric system

- **LOLE operational tends to be greater than the LOLE static** since it can capture not only the events with lack of generation capacity to meet the hourly demand but also events requiring additional load curtailment due to short-term capacity deficits
- When considering the expected NTC between PT-SP and SP-FR (100% NTC), the **adequacy of the static and operational reserve of the Portuguese system is considerably improved** (when compared with 10% NTC), with static and operational LOLE reducing from 5h/year and 11h/year to almost 0h/year, respectively;
- The 2nd scenario, "Conservative Estimates", **leads to increased power flows between Spain and Portugal**, because the Portuguese electric system becomes economically less competitive than Spanish electric system due to the greater RES generation available in Spain;
- The LOLE in the "Conservative Estimates" configuration of the Portuguese system **is mitigated if the expected NTC between PT-SP and SP-FR is deployed**. The EENS decreases from around 2100 MWh/year to less than 400 MWh/year;
- Increasing the NTC between PT-SP and SP-FR also leads to **less RES energy spilled**;
- The simulation of interconnected areas sharing common day-ahead markets and reserves is also an important advance **to identify bottlenecks** in generation and interconnection capacity, and to **assess the actual benefits** from an increasing interconnection between power systems.