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XXXVI Cycle

Assessment of allocation of the impact of RES penetration on Power System Security

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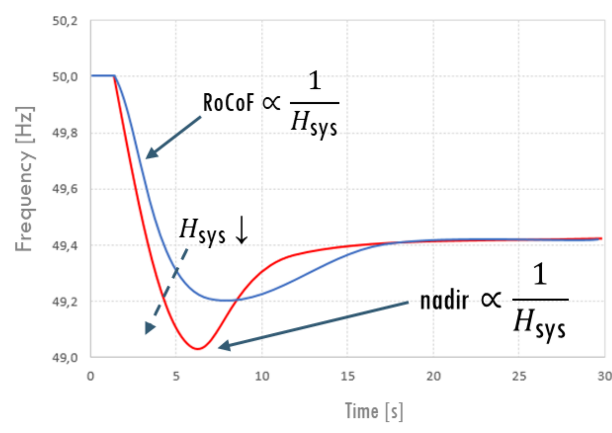
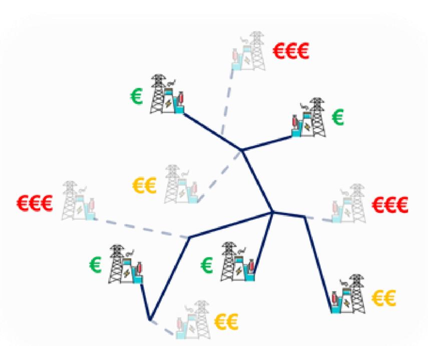
Research context and motivation

- The increasing amount of penetration of **Renewable Energy Sources** is leading to new challenges in managing and operating electricity transmission systems, particularly in the area of system stability. Specifically, IBPS *(Inverter Based Power Sources)*, including solar and wind, have an **impact on the inertia** of the power system.
- **Inertia is a key property** in the evolution of frequency transients, as it affects both the rapidity and the amplitude of oscillations, since when inertia decreases
  I. **RoCoF** *(Rate of Change of Frequency)* **increases**
  II. The **nadir** of the frequency transient becomes **deeper**





- Moreover, inertia, in an electrical system with a strong amount of IBPS, is considerably **variable** even in **short-term period**, due to **market** mechanism: only dispatched inertia is available, that is the sum of the inertial contributions of the generators operating in the network.

Novel contributions

- Traditionally, **frequency** is considered to be a **global property**, as its oscillations propagate very rapidly to the whole synchronous zone; for this reason, studies concerning inertia have so far been based on single-bus equivalents, in which the power grid was not modeled.
- For large systems, such as Continental Europe, the way in which inertia is distributed can have an impact on the dynamic response of the electrical system, being able to lead to **interarea oscillation**.

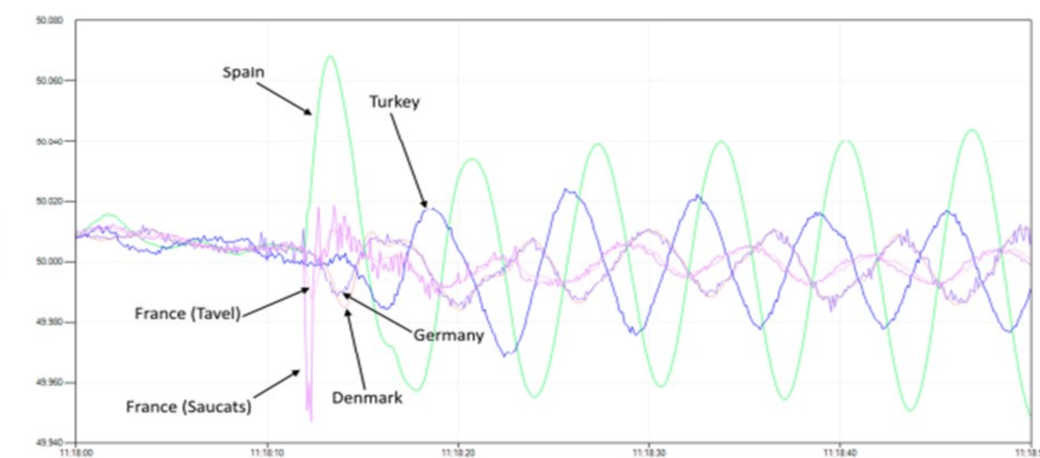


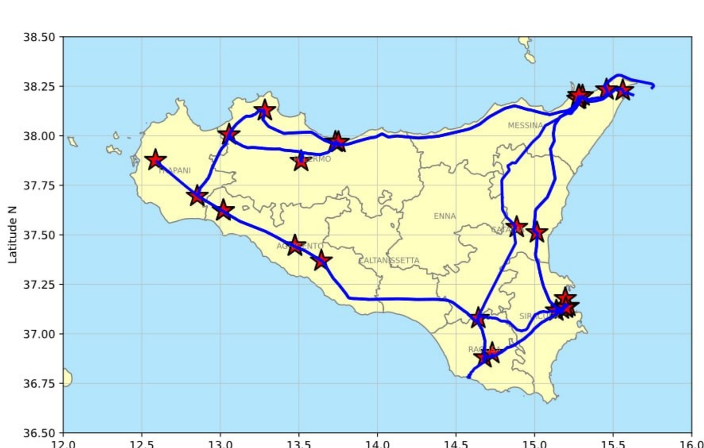
Image from ENTSO-E "Analysis of CE inter-area oscillations of 1st December 2016

- These analyses, therefore, must be performed in a new kind of model that takes into account **topology of the network** and **parameters of the lines**.

Adopted methodologies

- A complete **model** of the **Italian power transmission network** is under construction, starting from the TYNDP 2018 data on the network structure expected in 2030, to be used with *DigSilent PowerFactory* to run dynamic simulations with various contingencies (e.g. fault on a line, loss of a relevant power plant).

- **Static model has been completed**, with:
  - 575 sites
  - 1940 substations
  - 990 lines
  - 1105 transformers
  - 3069 synchronous generators
- Realistic **network models** for the transmission system and data to build them are usually **not publicly available**: for this reason, in addition to the main DigSilent model, a methodology to automatically build **realistic synthetic topological representations** of portions of the transmission networks starting from public maps has been developed.
- Adopted procedure is based on OpenStreetMap and is composed by a series of Python scripts that automatically retrieve, filter and process geodata to reconstruct the real topology of electrical power stations and high voltage lines, to link them correspondingly and to **estimate line parameters**.



- The proposed methodology was tested to reconstruct the power transmission grid of Sicily, Italy: all the 31 nodes (23 with max voltage of 220 kV, 8 with max voltage of 380 kV) and 46 lines have been correctly identified.

Future work

- To complete the DigSilent model of the Italian network, **dynamic behavior** of the **loads** and of the **equivalent of the European countries** will be modelled, with an approach based on layers of nodes gradually less dense as we move away from the Italian border.
- To study the interaction between **synthetic** and **physical inertia**, it's planned to perform a **Real Time Power Hardware In The Loop** simulation, in which a Marelli synchronous generator and an inverter driven with a control capable of generating synthetic inertia will be connected to a simplified model of a portion of the network.

Submitted and published works

- L. Solida, G. Chicco, E. Bompard, T. Huang, A. Mazza, M. Rapizza, *"Topological Aspects of Building Synthetic Models for Power Transmission Networks from Public Data"*, UPEC 2022 - 57th International Universities Power Engineering Conference, Istanbul, TR, August 30-September 2, 2022
- L. Solida, M. Rapizza, A. Iaria, D. Cirio, C. Gandolfi, *"Inerzia del sistema elettrico nel contesto dell'evoluzione del mix energetico"*, in "*Modello per la simulazione dinamica di modalità innovative di controllo della frequenza e analisi dell'evoluzione dell'inerzia*", Rapporto Ricerca di Sistema, RSE S.p.A., 2022

List of attended classes

Soft skills			
01UNXRV	Thinking out of the box	25/11/2020	*(1 h - 1.33 pt)*
01SWPRV	Time management	01/12/2020	*(2 h - 2.67 pt)*
02LWHRV	Communication	06/12/2020	*(5 h - 6.67 pt)*
01RISRV	Public speaking	11/12/2020	*(5 h - 6.67 pt)*
01SYBRV	Research integrity	16/12/2020	*(5 h - 6.67 pt)*
08IXTRV	Project management	10/01/2021	*(5 h - 6.67 pt)*
01SHMRV	Entrepreneurial Finance	13/01/2021	*(5 h - 6.67 pt)*
01QORRV	Writing Scientific Papers in English	20/05/2021	*(15 h - 20.00 pt)*
Hard skills			
01TRARV	Big data processing and programming	08/03/2021	*(20 h - 33.33 pt)*
02ITTRV	Generatori e impianti fotovoltaici	12/04/2021	*(25 h - 41.67 pt)*
01LEVRV	Power system economics	14/07/2021	*(16 h - 26.67 pt)*
02LGXRV	Valutazione di impatto ambientale di campi magnetici ed elettrici a frequenza industriale	19/07/2021	*(20 h - 26.67 pt)*
01TSBRV	Scienza dei dati applicata alle reti complesse	23/07/2021	*(20 h - 33.33 pt)*
01QUGIV	Energy in smart buildings	26/07/2021	*(10 h - 13.33 pt)*
01UJERV	Energy sustainability and security	01/09/2021	*(16 h - 21.33 pt)*
01LGSRV	Characterization and planning of small-scale multi-generation systems	17/09/2021	*(25 h - 41.67 pt)*
01DOPRO	Marine Energy	18/05/2022	*(20 h - 26.67 pt)*
02SFURV	Programmazione scientifica avanzata in Matlab	26/05/2022	*(30 h - 40.00 pt)*
01RGBRV	Optimization methods for engineering problems	07/06/2022	*(30 h - 50.00 pt)*
01DOARV	Electrical demand management	23/09/2022	*(25 h - 41.67 pt)*
External activities			
Summer School on Smart Grid - 7th edition *"Addressing the challenges of climate change"*		07/2022	*(25 h - 25.00 pt)*