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The impact of AC/DC network and system inertia on market zones

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Research context and motivation

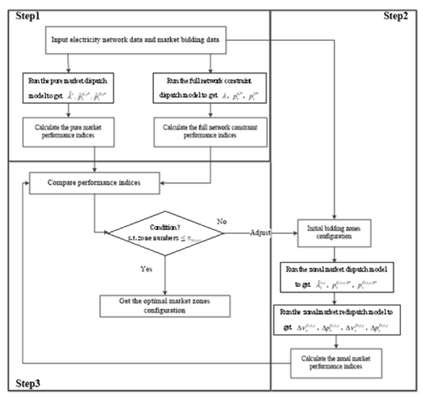
- The energy policy framework adopted by the European Union to facilitate the transition from fossil fuels towards cleaner renewable energy sources (RES) is drastically changing the European interconnected power system. Grid reinforcement, investment and new policies are needed to allocate a high level of RES, to reduce market electricity prices, and to increase the security of supply in future scenarios with a low number of conventional generating units, bringing to high capacity exchange between the national power systems.

- European wholesale markets for electricity are organized in bidding zones, which is one way to manage congestions in the transmission network. For a certain zone, there will be plenty of RES supplied by other zones in the future. As the network transiting the RES, the high-voltage direct current(HVDC) will cause various congestion state and then exert influence on the splitting of market zones together with AC network.

- The inertia of power system is a key aspect for frequency dynamics and stability. The increasing penetration of RES reduces the available inertia and makes it fluctuating, which causes problems for grid operators. There are interactions between market zones and system inertia .That is to say, system inertia has influence on the market zones. When splitting the market , inertia should be considered. On the contrary, the definition of market zones will also affect the distribution of system inertia. Their interplay is to be studied.

Novel contributions

- A preliminary framework has been constructed for the definition of the bidding zones, in which four different bidding mechanisms in three steps are considered, the model can be used to study the impact of AC/DC network and system inertia on the splitting of market zones in future research.

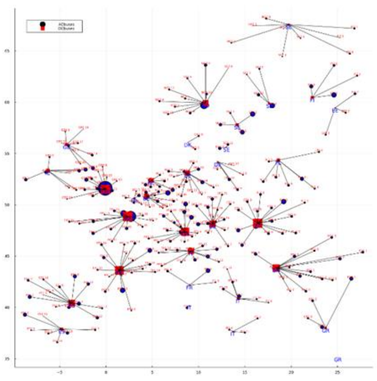


- The topological map of the 256 AC network and the 40 DC network has been made by collecting the longitude and latitude information of every nodes, and several different load scenarios (REF2030, REG2030, MIX2030, REF2050, etc) have been obtained by adjusting parameters of both supply side and demand side, in which the data from ENTSO-E are considered.

Addressed research questions/problems

- The Matlab package of the market zones assessment indices has been completed. Here four different bidding mechanisms are considered: the market dispatch without any constraint, the market dispatch with full network constraints, the zonal market clearing as well as the zonal market redispatch.

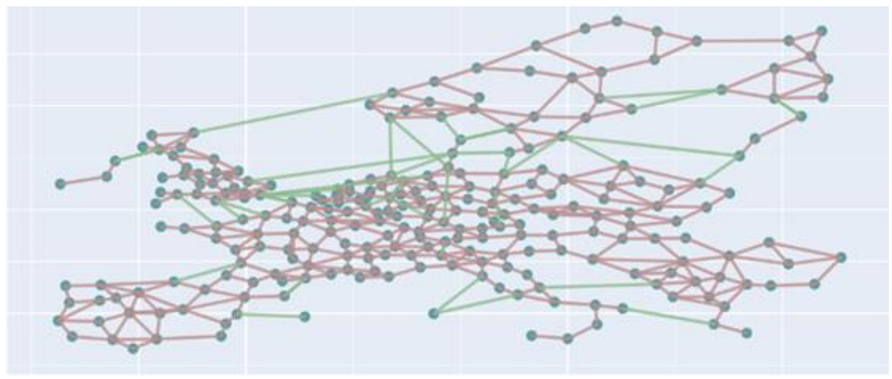
- The relationship among DC buses and load nodes has been obtained. In the research, a specific proportion of electricity demands will be supplied by RES from DC buses, and by figuring out their topological relationship, it can be known that for a ceitain DC bus ,which load nodes should it absorb.



- The problem of the unreasonable power flow outputs of slack buses has been addressed. In Pypsa, the original power setting of DC links are zero, which means they does not work in the software. That is to say, every zones operate independently. If the power flow is run by Pypsa directly, the output of the slack buses can be unreasonable huge or small. However, these DC links interact among each other and it is difficult to figure out their relationship. To solve this problem, I produced a Pypsa package to adjust the input settings of every DC link so we can obtain reasonable convergent outputs. By doing this, one of the barriers to future research has been cleared.

Adopted methodologies

- In my research, Power flow method is adopted to analysis different load scenarios of the 256 AC/DC network. The network components information are provided by Pypsa-Europe, and the real and reactive power flow through each AC line DC link can be computed by Newton-Raphson Methods and hence losses in a system.



- Optimization methods are used to decide that for every AC bus, which is the right DC nodes should their generation move to. In the objective function, factors such as geographical distance and the allocated value are considered, and the constraints includes mapping relations among AC and DC buses in terms of topology.

Future work

- Future work will focus on the research about how AC/DC network structure and system inertia distribution affect the proposed assessment indicators of market zones.

- A performance based model for market zones definition is to be built

Submitted and published works

List of attended classes

- 01NDLRV – Lingua italiana I livello (Date:17/02/2022 ,credits:3)
- 01UNVRV – Navigating the hiring process: CV, tests, interview(Date:22/08/2022, credits:1)
- 01RGBRV – Optimization methods for engineering problems(Date:07/06/2022, credits:6)
- 01LEVRV – Power system economics(Date:07/09/2022, credits:3)
- 02SFURV – Programmazione scientifica avanzata in matlab(Date:21/04/2022, credits:6)
- 01RISRV – Public speaking(Date:05/09/2022, credits:1)
- 01DOCRV– The Hitchhiker's Guide to the Academic Galaxy.That is:Basic knowledg(Date:16/06/2022, credits:4)
- 01QORRV – Writing Scientific Papers in English(Date:16/06/2022, credits:3)
- 01UQONC– e-Transition, Sustainability and Economics(Date:21/06/2022, credits:10)