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The current ambitious decarbonization targets set in the European Union and in the world, make it necessary to resort more and more to Renewable Energy Sources (RES), often connected to distribution grids.
However, increasing the penetration of non-dispatchable RES generation is feasible only if opportune measures are adopted to guarantee the stability of the fundamental parameters (frequency and voltage) characterising the electric system.
To this aim, real-time balancing markets are becoming more and more important in order to ensure the needed system services. It is under discussion the possibility to shorten the gate closure of balancing markets from 15 minutes to 5 minutes ahead of real-time (as already adopted in the USA).
Flexible resources (storage and demand-side management) are becoming strategic in order to allow a local compensation of all deviations of RES generation schedules from the predicted values, preventing them to be propagated to the whole system.
Grid planning is also becoming more complex and affected by uncertainty. The high variability of RES generation patterns creates a kind of line congestion that, unlike the traditional one, yet maybe frequent doesn't last long time. So, the deployment of new lines could prove not economically optimal. Additionally, deploying new lines requires a long-time-ahead analysis which needs certainty on which generation and load resources will be available in the system. By contrast, RES deployment plans are often uncertain and vary very frequently. So, this scenario analysis becomes more complicated and affected by uncertainty.
Finally, the deployment of new lines is nearly always strongly delayed by public opposition and by the application of cumbersome formal procedures to evaluate environmental compatibility of new grid lines.
By contrast, flexible sources, which are being deployed more and more in the system (both connected to transmission and distribution grids) could provide a way to avoid big investments in new lines and strongly reduce the time needed to solve grid congestion (investments can be done in a shorter time, require only local permissions and are of lower economic dimension, thus being justified also in case of frequent but not-long-lasting RES congestion).
However, assessing whether a new line or the deployment of flexible resources should be preferred requires to solve a huge optimization model (Optimal Power Flow - OPF) minimising the sum of CAPital EXpeditures (CAPEX) and Operation EXpenditure (OPEX) for the whole system (transmission + distribution).
Moreover, as a good share of flexibility is deployed in distribution, it becomes crucial to coordinate transmission and distribution planning, so far completely disjoint. Such coordination could potentially prove problematic due to the huge size of the system encompassing transmission and distribution grids and due to the fact that transmission and distribution grids are managed by different system operators, which would be for sure interested to retain a certain degree of independence as well as a private management of their relevant data.
The methodology and the new set of tools deployed by the FlexPlan Horizon 2020 project (https://flexplan-project.eu/) aims at realising a step forward in the grid planning methodology allowing to tackle all the issues mentioned above. This new methodology, instead of analyzing a new investment at a time and considering its economic impact with respect to the status quo situation, elaborates a set of potentially interesting investments (candidates) and analyses all of them in one shot by determining the combination that minimizes the sum of CAPEX and OPEX. The formulation of this problem results in a large Mixed Integer Linear Problem (MILP), which becomes numerically treatable due to the usage of decomposition techniques (Benders decomposition and decomposition between transmission and distribution planning).
The new FlexPlan methodology includes many other advanced features: i) integrated transmission-distribution planning; ii) embedded environmental analysis on air quality, carbon footprint and landscape constraints; iii) simultaneous mid- and long-term planning calculation over 2030, 2040 and 2050; iv) analysis of the variability of RES and load time series through yearly climatic variants resulting in a probabilistic optimization model; v) full incorporation of cost-benefit analysis into the target function; and vi) probabilistic security criteria replacing the traditional N-1 criterion. These unique features represent an important step forward with respect to state-of the-art grid planning tools. Six regional cases covering nearly the Whole Europe are used as a test-bed for the validation of methodology and tools and they will result in a set of data enabling to perform an analysis of the amount of flexibility that will be needed in Europe in the mid-long time in order to achieve the wished high RES penetration levels till 2050.
However, the adoption of this new methodology also requires eliminating some regulatory barriers that could make its adoption complicated or even impossible:

- Investments in storage and flexibility will remain mostly in the hands of private investors. National Regulatory Authorities should translate the suitability of deploying new storage or flexibility in strategic network

locations into opportune incentivization to potential investors. This complicates the traditional scheme, where System Operators after carrying out planning analyses were the only subject entitled to invest.

- As already mentioned above, considering the support of flexibility to grid planning requires to coordinate transmission grid and distribution grids planning, yet maintaining the specificities of each and allowing the different system operators not to share private data. The new FlexPlan methodology elaborates a T&D decomposition scheme which could constitute a practical way to implement this.
- The new planning methodologies valorising the role for system flexibility must match a new real-time market architecture able to favour bidding from flexible resources. As these resources are often of small size, not allowed to directly bid in the real-time markets, the regulators should also pay attention to the new figure of the aggregator, providing a regulation able to enforce a credible and financially sustainable role for it.