Optimisation of multi-year planning strategies to better integrate renewable energies and new electricity uses in the distribution grid

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Abstract:

The planning of electricity distribution grids is expected to evolve quickly to not only incorporate an increasing number of electricity production facilities based on Renewable Energies (RE) but also to anticipate the introduction of new electricity uses such as electric vehicles and energy storage equipment.

This new reality can cause the need for work on the grid that is costly and long to implement. Different research centres, including EDF R&D, assign resources to the development of solutions capable of easing the integration of REs and new electricity uses into the distribution grid: advanced voltage regulation, temporary renewable production curtailment ...

EDF R&D and CentraleSupélec/L2S cooperate since 2012 to develop a decision support tool for the multi-year planning of distribution grids with the introduction of renewable energies [1]. Using this tool and for a given network, different planning strategies representing different approaches can be studied, while taking into account uncertainties regarding the deployment of renewable energies. EDF R&D is interested in using this tool to identify the best planning strategies to apply to a given family of networks (rural networks, urban ...).

Until now the research into the optimisation of planning strategies has consisted in minimising the expected cost of a bi-variable strategy through the use of Bayesian optimisation algorithms such as IAGO [4], TTPS and PTS [3]. The tested algorithms showed interesting performances in a simple case but do not seem however entirely adapted to the future needs in terms of optimisation:

- Expected cost may not be the best criterion for measuring the effectiveness of a strategy. Statistical indicators that are more relevant but also more difficult to estimate should be considered;
- The optimisation of a single objective, such as the average cost, is not satisfactory if one considers the complexity of the problem on the Distribution System Operator (DSO) perspective. Multi-objective and/or constrained formulations must, therefore, be studied [2];
- A DSO eventually prefers to know the near optimal areas of the solution space, satisfying a tolerance on objectives, rather than the exact solution. This way of considering optimisation does not seem to have been considered in the literature.

In order to develop the existing tool several steps were identified: model new multi-variable planning strategies, including new technical solutions; define criteria to measure the effectiveness of the planning strategies; propose different possible formulations of the optimisation problem, including several objectives and/or constraints potentially contradictory and/or difficult to estimate; develop optimisation algorithms adapted to the peculiarities of the problem; demonstrate the interest of algorithms in case studies, including different REs penetration rates, planning strategies and distribution network families.

In this presentation, the overall problem and the initial exploratory work regarding criterion to measure the effectiveness of planning strategies shall be presented.

References

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[4] Julien Villemonteix, Emmanuel Vazquez, and Eric Walter. An informational approach to the global optimization of expensive-to-evaluate functions. *Journal of Global Optimization*, 44(4):509–534, 2009.

Short biography – With a background in Industrial Engineering and Management (University of Lisbon), and a Master Degree in Renewable Energies (Ecole Polytechnique), Bruno began his PhD in November 2018 with CentraleSupélec and EDF R&D.
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