Study Committee C2

POWER SYSTEM OPERATION & CONTROL

11098_2022

Training Platform for Proof of future Dispatcher Tools

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Motivation

- Looking at the ongoing phase-out of nuclear (and now also of coal), the German WindNODE/SINTEG consortium has been testing solutions to balance the generation and consumption of renewable electricity.
- New regulation of congestion management in Germany (Redispatch 2.0) - Reduction of capacity limit for generation and storage units to 100 kW, increasing unit number.
- As key component of a grid congestion management tool, a local ancillary services market mechanism was designed.
- Since dispatcher trainings must be adapted to the future grid state, a test environment for dispatchers was developed allowing the testing of future-oriented system operation tools with special focus on locational system ancillary services market mechanism, especially grid congestion management.

Method / Approach

- A 10-year future scenario (2030) for the control area of the TSO 50Hertz was implemented into a SCADA-based dispatcher training simulator based on the German grid development plan for electricity (release 2017 for 2030).
- Modelling of more than 300 flexibility options installed at DSO level that represent future installed capacities for power-to-gas, power-to-heat, and batteries.
- A local ancillary services market mechanism is designed based on GAMS (General Algebraic Modeling System) using state-of-the-art solvers extending on the Optimal Power Flow tools GAMSPower optimizing the operation with the dispatcher maxim to produce flexibility schedules to relief congestions.

Objects of investigation

- The grid is modelled in a direct current load flow (DCLF) approach including losses that can be extended to a full ACLF-model when reactive power needs to be considered.
- The interdependencies of the effects due to the decentral flexibility options are fully incorporated by the algorithm.
- The schedules are transferred to the training simulator and can automatically be put into execution by the dispatcher after a security evaluation, thereby reducing the operation of hundreds of flexibility options to few commands.
- The optimization horizon of the scenarios for the exemplary 4.25 hours with a time-resolution Δt of 15 minutes is leading to 17 time-steps. The data was extracted from the dataset to cover a time period where a strong wind front is hitting the grid leading to congestions.
- The scenarios are distinguished by the power of the battery installed at each 110 kV node, whether the capacity of the BESS can be fully employed for the optimization and if there is the option for P2X installed at the node.

Experimental setup & test results

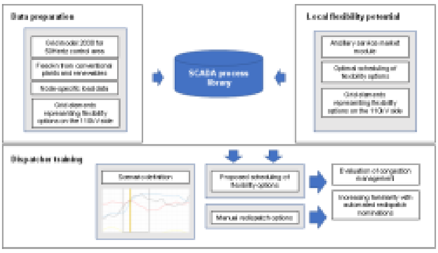

Fig. 1: Overview of the proposed research design

Discussion

- In contrast to today’s training concepts, dispatchers must instantaneously control many smaller generation and storage units. This requires a high level of confidence in the pre-calculated scheduling.
- The training system proposes solutions for grid congestion based on a projected state of the grid. The trainees cannot apply the results to current network problems.
- The optimal scheduling depends on the concrete regulation of the redispatch (cost-based- vs. market-based).

Conclusion

- Demonstration how to control implemented decentral flexibilities under different operational conditions to get an optimal grid effect.
- Analysis of practical application of a dispatcher tool intended to minimize RES curtailment measures within the framework of grid congestion management.
- Complexity of optimizing the use of the more than 300 implemented decentralized flexibilities requires the application of an optimization algorithm.
- Dispatchers to deal with such automated decision tools in system operation, as they will no longer be able to cope with the growing complexity themselves.
- Shown that the minimal demand for flexibility is related to security thresholds on branch levels in a non-linear manner, depending not only on flexibility in terms of power but also in terms of energy.
- Through the implementation of the scenarios in the training simulator, dispatchers today can gain and share experience to support the development of such tools in the near future.

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Insights into the optimization results

- The first step is to analyze the impact of the proposed flexibility options on the load levels to gain insight in the congestion that is posed by the scenario “reference”. Therefore, in Fig. 2 the load levels of the branches are displayed for two distinguished time steps.
- For time-step t = 7460, the load level of every branch is below 70%, which is an indicator for the observance of the (n-1)-criterion, whereas at a later time-step t = 7472, branch L490 has a level over 70% indicating a congestion.

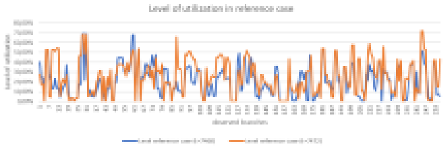

Fig. 2: Level of utilization of observed branches in reference case.

- By incorporating the defined scenarios, applying the optimization problem for the constraints and minimizing the goal function, the load levels of the branches are reduced. This is depicted in Fig. 3 below.
- The blue curve represents the reference scenario for comparison, and it is obvious, that each scenario comprising flexibility options suffices to decrease the load level of the congested line L490 below the 70 % boundary.

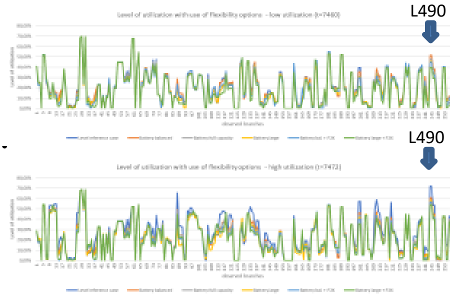

Fig. 3: Load level of observed branches under the influence of flexibility options for time-steps t = 7460 (upper panel) and t = 7472 (lower panel). The congested line is driven below 70 %, thus re-establishing (n-1)-security.

- A deeper insight into branches L490 and L920 is shown in Fig. 4. It reveals that the optimized operation scheduling of the flexibility options has a smoothing effect on the load levels over the time. This is related to the goal function, where all time steps are weighted equivalently.
- The figures show the time series of load levels of line L490 and L920 as result of the optimized operation of flexibility options.
- The complex action of flexibility options on the grid leads to trade-offs between load levels, e.g. in scenario “BESS balanced” (grey), the load level of line L920 is raised for several time-steps compared to the reference case (orange).
- Due to the complex effects of introducing flexibility options on the grid, every branch is affected, leading to trade-offs between the load levels of branches. Focusing on line L920, the load levels in the scenario “BESS balanced” are raised for several time-steps compared to the reference case.

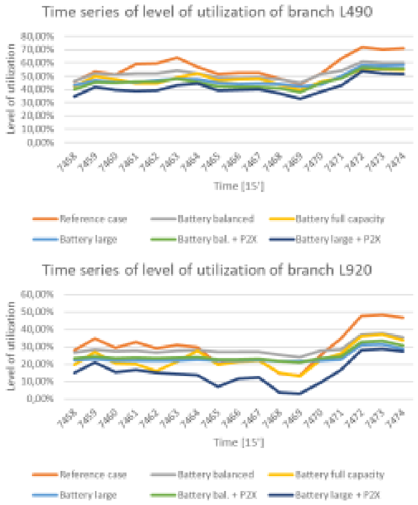

Fig. 4: Time series of load levels of lines L490 (upper panel) and L920 (lower Panel) due to the optimized operation of flexibility options.

- A deeper insight is provided in Fig. 5 regarding the schedules for the flexibility options determined by the optimization. The figure exemplarily shows the schedules for the scenario “Battery full capacity” and “Battery full + P2X”.
- By overlaying all schedules, it becomes clear that the optimal scheduling for a larger amount of additional technical units require complex operational controls that can only be provided by automatization.
- When flexibility options can be used with their full storage capacity and eventual load or in-feeds are balanced at later time, the flexibility options are driven in a mostly synchronous way leading to the thinning out of distinct schedules as depicted in Fig 5.

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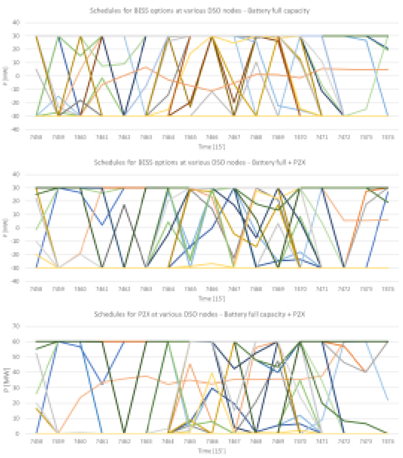

Fig. 5: Schedules for BESS flexibility options in scenario "Battery full capacity" (upper panel), BESS flexibility options in scenario "Battery full + P2X" (middle panel) and P2X flexibility options in scenario "Battery full + P2X" (lower panel). Comparing upper panel against middle and lower panel in combination reveals the alteration of BESS schedules when P2X is adjoined.

- A detailed comparison shows that employing additional P2X also effects the schedules for the batteries.

Insights into the preparation of future-oriented dispatcher trainings

- The future-oriented demonstration trainings with the focus grid congestion management based on locational system ancillary services market mechanism were carried out at the DNV/GridLab dispatcher training centre in Schönefeld near Berlin.
- Some facts about the training centre: It has two training areas that can be separated or combined, with a total of sixteen individual training places, four trainer places and a briefing area as well as modern presentation technology, see Fig. 6.

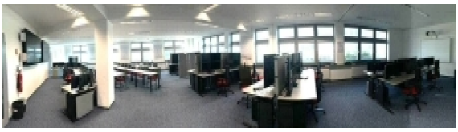

Fig. 6: A sight into the dispatcher training center.

- The training environment enables a realistic control room atmosphere. The SCADA-based dispatcher training simulator is based on PSIcontrol.

Fig. 6: Workplace of trainers (left) and trainees (right).

- On behalf and in cooperation with the University of Leipzig, from July 2017 to January 2021 DNV/GridLab created a test environment for dispatchers allowing the testing of future oriented system operation tools with special focus on locational system ancillary services market mechanisms.
- The project in context of the WindNODE initiative was part of the SINTEG program. WindNODE: https://www.windnode.de/en/. SINTEG: 'Smart Energy Showcase' (SINTEG) program of the German Federal Ministry for Economic Affairs.
- The creation of the test environment was conducted in following steps:
  - Implementation of the 10-year future electricity scenario (grid topology, generation and loads and dispatch time series according to the German TYNDP 2017) into the SCADA-based dispatcher training simulator (DTS),
  - Implementation of in total 315 decentral flexibilities (+/- 30 MW battery energy storages (BESS), 30 MW power to heat (P2H) and 30 MW power to gas (P2G) installations) into the DTS,
  - In cooperation with experts of the University of Leipzig: Implementation of regional ancillary services market mechanisms for the decentral flexibilities into the DTS based on linear optimization algorithm,
  - Operational application and visualization of how regional ancillary services market mechanisms work and contribute to reducing transmission line N-1 overloads,
  - Due to COVID-19 the final test training in January 2020 was conducted as webinar with 68 participants from TSOs, DSOs, utilities, OEMs and wind farm operators.