FLEXIBILITY FOR MARKETS AND GRIDS: ECONOMIC AND TECHNICAL EVALUATION OF THE HYBRID-VPP CONCEPT

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Overview

The increasing penetration of distributed renewable generation requires a transition of existing distribution grids as well as high investments in order to deal with the challenges of changing power flows in the grid. Smart grid technologies are intended to support the grid operation and lower the required investments, but in many cases, their economic feasibility is challenging. Additionally, virtual power plants play an important role throughout Europe for pooling of distributed generators and consumers as well as for trading their flexibility on several power markets; thereby they further increase the difficulties of operational planning in the distribution grids from DSO perspective. On the other hand, virtual power plants could also play a major role in supporting distribution grid operation if they were expanded by certain smart grid technologies.

To address this idea, a concept for hybrid virtual power plants (hybrid-VPPs) was developed in scope of the project hybrid-VPP4DSO[1]. A hybrid-VPP has the intention to support the distribution grid operation in parallel to the usual operation on power or balancing markets. Therefore a coordination scheme between the DSO and the hybrid-VPP operator was developed, using a traffic light concept [1]: In grid sections, which are in the green state, market participation is possible without limits. In the yellow state, a grid section is close to its limits (voltage or loading wise) and market participation for the hybrid-VPP gets restricted. Finally, if a grid section is in the red phase and thus faces some voltage or overloading problems, the grid requests active support from the hybrid-VPP.

Different use cases for a hybrid-VPP operation are presented and the potential benefits for the different market stakeholders and the distribution system operator (DSO) as well as possible regulatory barriers are discussed. These use cases can be categorized in market driven, customer driven and grid driven. In the second part of the work, the use cases are analysed from a technical perspective and assessed economically by means of scenarios based on real distribution grids and ancillary service markets in Austria and Slovenia.

Methods

Initially the identified use cases were analysed from a technical perspective. The concept of the hybrid-VPP and its ability to support the DSO was investigated by means of power flow simulations in grid sections of a DSO in Austria and in two regions in Slovenia. The coordinated operation of the hybrid-VPP was simulated for a whole year in 15min intervals, taking into account the DSO's restrictions and activation orders with first priority as well as activation orders derived from participation in the market for tertiary control with second priority. The impact of the hybrid VPP operation on the state of the distribution grids was evaluated by sub-sequent load flow simulations.

The results of these simulations were used for break-even analyses for the operation of a hybrid-VPP in the two countries Austria and Slovenia. The revenues of provision of flexible capacity to the balancing markets and the day-ahead and intraday spot markets were calculated for the investigated scenarios and use cases. The revenues were compared with the costs of the VPP installation and operations. Therefore, realistic reductions of market revenues due to the grid support and costs for the participation in the hybrid-VPP were compared with investments costs of DSOs or new grid customers.

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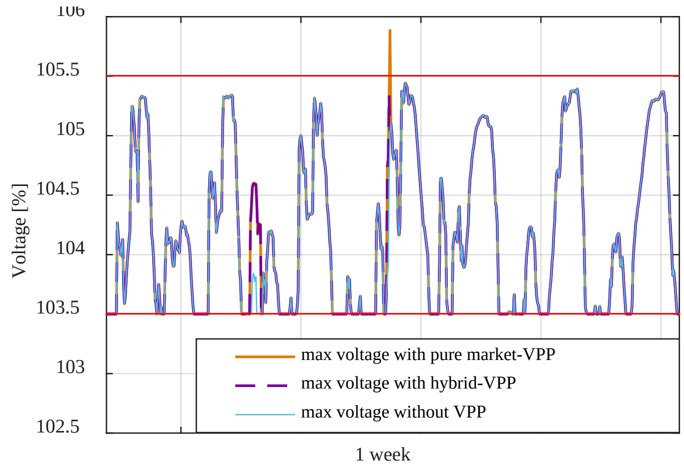
Results

The project hybrid-VPP4DSO successfully demonstrated the potential of a hybrid-VPP to support local distribution grid operation in parallel to active participation in a national market for tertiary control.



The figure to the right shows the results for one of the analysed use cases: Due to an increase in connected customers, the analysed grid section faces a yellow phase during several times of the year. The maximum voltage in the grid (blue) is close to its upper limit. With a conventional VPP additionally participating on the balancing market, the upper voltage limit would be violated (orange). The DSO would therefore most likely not permit the market participation in a pure market-VPP in this grid section. However, if instead a hybrid-VPP participates in the market, considering possible restrictions from the grid, those voltage band violations can be prevented (purple). The economic assessment of this use case found that the revenues for the hybrid-VPP are reduced by 10%, since more backup resources are needed due to the grid restrictions. The calculated dynamic investment appraisal showed a payback time of only 1.3 years for the hybrid-VPP in this use case.

The applicability of the hybrid-VPP depends on the grid topology and the connection points, capacity and type of available flexibilities. The simulations showed that a pool with units that are diverse in location and include demand side management as well as different types of (renewable) generators is recommended in order to be able to successfully support the distribution grid operation throughout a whole year.

Conclusions

In the future electricity system the need for flexibility is likely to increase due to the continued expansion of volatile renewable energy sources. Demand side management and distributed energy resources can play an important role as providers of flexibility without the need of high investments, in particular when a VPP is already in operation for other purposes. The hybrid-VPP can support the future electricity system by coordinating those flexible units and thereby increasing their economic value. The project hybrid-VPP4DSO successfully demonstrated the potential of a hybrid-VPP to support local distribution grid operation in parallel to active participation on a national market for tertiary control. The added value of a hybrid-VPP is mainly related to the multitude of different use cases (e.g. the reduction of investment costs for new users who connect to the grid and the prevention/deferral of grid investments of DSOs), which can be implemented using the same hybrid-VPP platform.

References

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