Smart Grid-Enabled CVR: An Advanced Application for Distribution Management Systems

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Abstract

- A multilevel, multitasking smart grid-enabled conservation of voltage reduction (CVR) control and optimization methodology is proposed for advanced distribution management system (ADMS) platforms.
- The first level deals with the centralized optimization of volt/VAR optimization (VVO) devices; the second-level is for voltage control in the local domain or decentralized control; and the third level assesses the energy savings and CVR factor.

Smart Grid-Enabled CVR and Optimization

The task of the VVO processor is to optimize the settings of the VVO devices for the CVR objectives. The ranges of the CVR duration and CVR voltage are set by the system operator according to operational requirements.

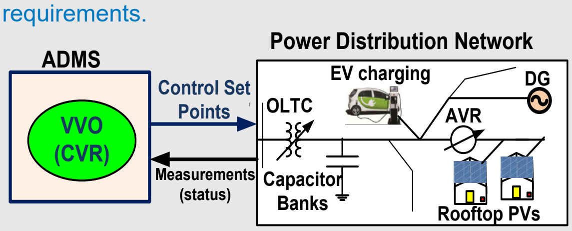


Fig. 1. Closed-loop framework for CVR operation

Mathematical Formulation and Implementation

- *First layer:* Centralized control and optimization using multi-objective particle swarm optimization (PSO)

$$f_1 = \min\left\{ \sum_{a,b,c} \sum_{k}^{n-1} \left(V_{CVR,h} - V_{k,h}\right)^2_{a,b,c} \right\}$$

$$f_2 = \min\left\{ \sum_{a,b,c} \left(P^{a,b,c}_{loss,h} + jQ^{a,b,c}_{loss,h}\right) \right\}$$

- *Second Layer:* Local voltage control using volt/VAR droop controller
- *Third Layer:* Calculation of savings and CVR factor.

$$CVR\ factor = \frac{\Delta W\%}{\Delta V\%}$$

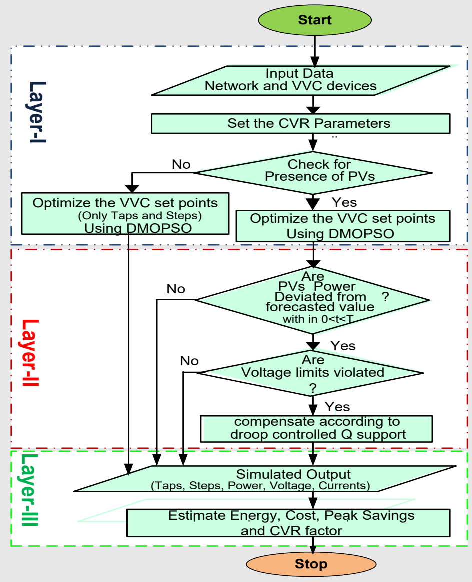


Fig. 4. Flowchart of implementation of proposed method

Simulations and Result Discussion

- The proposed method has been validated on a modified IEEE 123-bus distribution test feeder in the presence of three photovoltaic (PV) units during peak demand hour.
- The Q set points for smart PV inverters are obtained through centralized control, and the local voltage controller provides the Q set points to the PV inverter during PV power variations.
- Fig. 2 and Fig. 3 show some key results using OpenDSS and MATLAB.

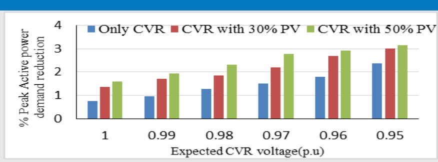


Fig. 2. Percentage peak active power demand reduction according to different CVR voltages

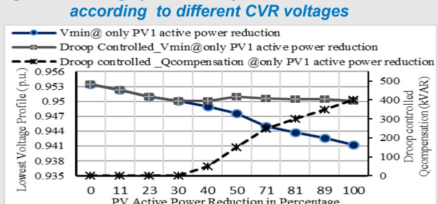


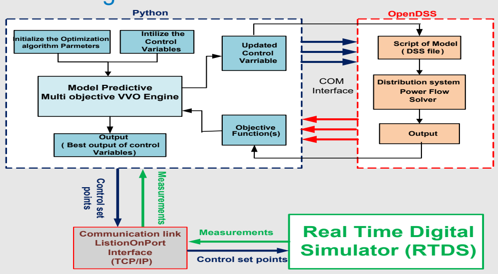
Fig. 3. Lowest voltage profile during different percentages of PV active power reduction

Conclusion

- Higher energy and peak savings have been achieved through the deployment of CVR with a PV system.
- The proposed multilevel, multitasking CVR scheme does not result in voltage violations even with increased PV penetrations and deeper voltage reduction.
- The proposed control scheme is also capable of handling the voltage fluctuations during cloud transients.

Future Work

Development of a real-time VVO framework considering uncertainties



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This work was authored Department of Electrical Engineering, Indian Institute of Technology (Banaras Hindu University) Varanasi, U. P., India by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by Indo-US Science & Technology Forum, India under the Bhaskara Advance Solar Energy Fellowship-2018 .

2018 IEEE POWER AND ENERGY SOCIETY GENERAL MEETING
Portland, Oregon
August 5-9, 2018
NREL/PO-5D00-71946