Management and Optimization of VARs for Future Transmission Infrastructure (MOVARTI)

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With a changing mix of generation sources, including more natural gas, renewable energy and distributed energy systems, it brings much greater uncertainty on planning and operations of the power system. As new generation comes on-line at the same time older coal-fired units are idled or retired, utilities are seeing an increasing number of voltage issues across their service territories. Companies are making investments in technologies, such as static VAR compensator, without a clear picture of what the future looks like. ORNL is working on a tool that will help determine the value of a VAR to assist in the decision making process for utilities.

MOVARTI

An integrated VAR planning tool that has the following functions:

- Identify VAR-related issues for existing and future power grids comprised of diversified generation sources especially the intermittent renewables, and/or with system topology/configuration changes. Define new voltage stability indices (VSI) to incorporate such generation diversity.
- Graphic user interface (GUI) to integrate different power system analysis tools and to provide visualization of the result.
- Provide VAR size, location, and type (static or dynamic) planning solutions by performing multi-scenario static power flow and post-contingency dynamic voltage stability analysis.
- Perform VAR benefit analysis to assess the value streams of a VAR planning result or to find the optimal solution of VAR source investment with constraint budget.

Integration of Power System Tools

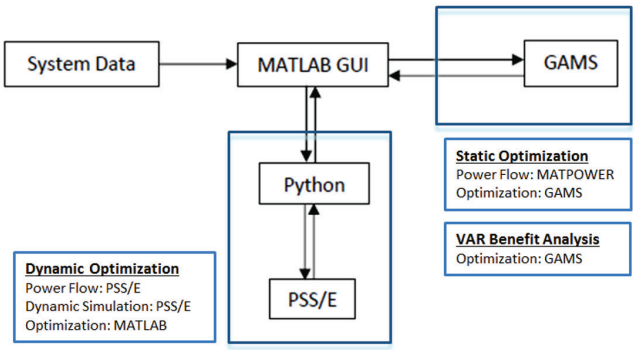
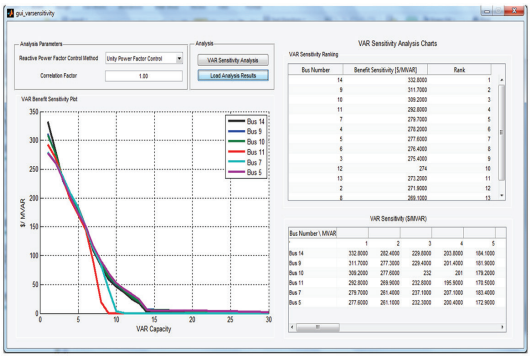


Diagram of the VAR planning tool components



VAR benefit sensitivity analysis GUI

The GUI provides a common platform (MATLAB) to integrate three power system analysis programs (GAMS, PSS/E, and Python) through a graphical interface that allows users to select different generation types and their penetration levels along with other system properties as inputs to set up the simulation and perform the analysis. It also provides visualization capabilities to easily observe the results obtained from the analysis. The capabilities of the GUI can be summarized as combining and accessing the computational capabilities of GAMS and Siemens PSS/E to provide the user a common interface to perform the voltage stability constrained reactive power planning and VAR value sensitivity analysis studies.

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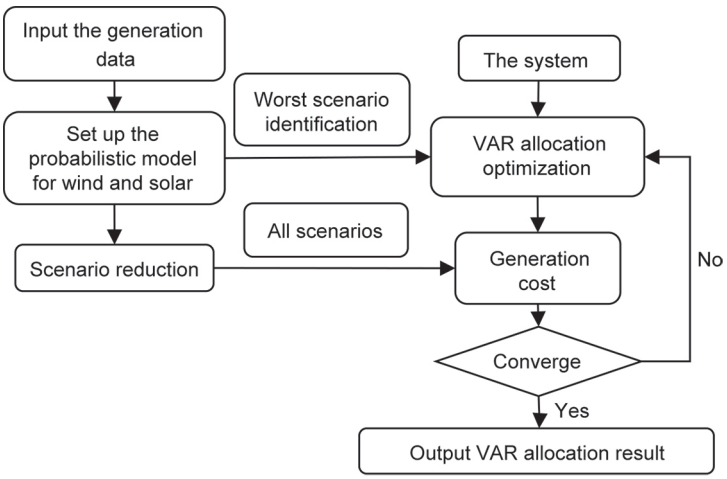
September 2014

Static Voltage Constrained VAR Planning



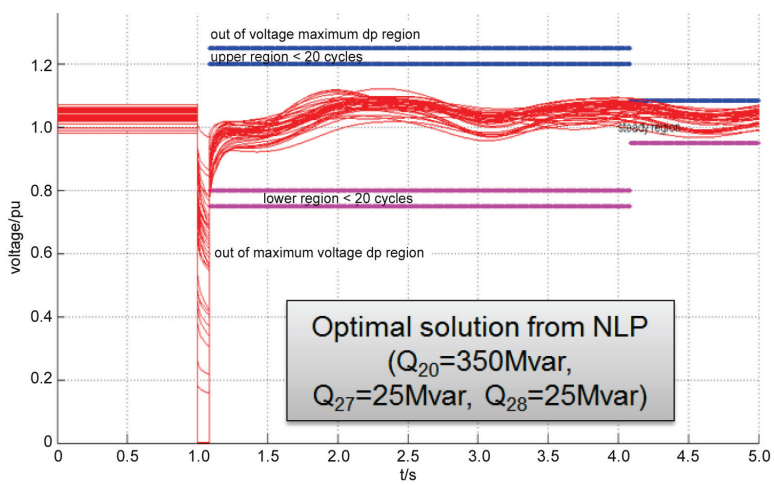
Flow chart of static voltage constrained VAR planning considering different generation mix

A two-stage stochastic programming optimization model solves the voltage stability constrained VAR planning problem considering various generation mixes. A probabilistic output model for both active and reactive power from wind power or solar PV is employed. Conventional generators are also modeled using the deterministic D curve. Both the VAR sources investment and the generation costs are considered.

Dynamic Voltage Stability Analysis

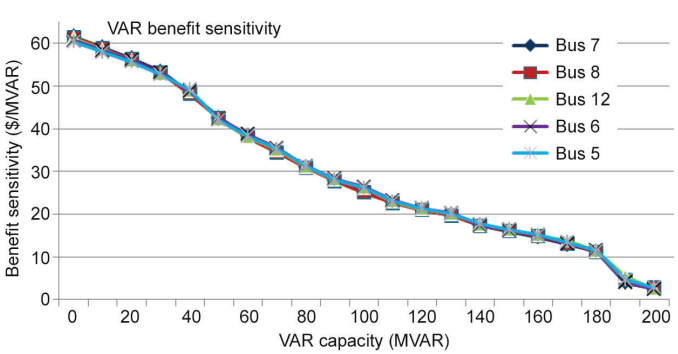
Based on the results from static VAR planning, a new approach for optimization of dynamic VAR source allocation has been developed with the following steps to address post-contingency voltage instability issues:

- Contingency ranking and screening to identify the most critical contingencies
- Placement of dynamic VAR sources using trajectory sensitivity analysis on post-contingency simulations
- Optimization of the size of dynamic VAR sources by a heuristic searching algorithm



Post-contingency voltage rajectories with dynamic VAR support

VAR Benefit Analysis



VAR benefit analysis

The benefit from VAR compensation is decomposed into three parts: reduced power losses, shifting reactive power flow to active power flow and increasing line transfer capability. The VAR benefit sensitivity of system buses is calculated and ranked. The most sensitive buses are tested with a large VAR size range.

By installing VAR sources on the most VAR-benefit-sensitive buses, real power generation can be shifted from the more expensive generators to the less expensive ones, system losses can be reduced because VAR support is closer to the load center.