Determining Optimal Mitigation Measures to Improve Transmission System Reliability in Real-Time

V&R Energy
www.vrenegy.com

Staff Technical Conference on Increasing Real-Time and Day-Ahead Market Efficiency through Improved Software
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1. About V&R Energy
AUSTIN, Texas, April 6, 2011 -- /PRNewswire/ -- The Clean Technology and Sustainable Industries Organization (CTSI) and its committee of utility and system integrator technologists from Lockheed Martin, Austin Energy, National Grid, Northeast Utilities and the City of Anaheim recognized V&R Energy as the 2011 Top 15 Utility Solutions
V&R Energy

V&R Energy, a California-based company, is a leading provider of the Next Generation software solutions for the electric power industry, in business since 1992
- Vendor for Physical and Operational Margins (POM) Suite

Recent V&R Energy’s awards are:
- ARRA ISO-NE Synchrophasor Infrastructure and Data Utilization (SIDU) Project, 2010
  - “Region of Stability Existence” (ROSE) is a part of ISO New England winning bid
- DOE Award: “20% Wind by 2030: Overcoming the Challenges”, 2010
  - Improving Reliability of Transmission Grid to Facilitate Integration of Wind Energy in Tri-State G&T and AECI
- NYSERDA Award, 2010
  - Prevention of Occurrence of Major Catastrophic Events: Demonstration for Con Edison System
V&R Energy Customers
User Testimonials

- I'm convinced you (plural) are the only ones in the industry giving the proper thought and attention to the problems that transmission operators and planners are trying to manage
  - American Transmission Co.

- When POM is utilized for planning studies, the person-hours spent could be in the ratio 1:4 compared with the software presently used, which translates to about $50,000 in productivity gains
  - New York Power Authority

- V&R Energy’s software allows us to do in 20 minutes what normally takes about seven hours with our present system
  - East Kentucky Power
Latest Papers on the Use of V&R Energy’s Technology

Paper “Calculation and Visualization of a Power System Stability Margin Based on the PMU Measurements” was presented at 2010 IEEE SmartGridComm, Gaithersburg, October 4-6, 2010:

Three papers were presented at 2010 PES T&D Conference and Expo, New Orleans, April 19-22, 2010:
- "Implementation of Optimal Mitigation Measures for Transmission Planning Assessment"
  - by Jason Robison, Makarand “Mak” Nagle, Southwest Power Pool, Marianna Vaiman, V&R Energy
- "N-1-1 AC Contingency Analysis as a Part of NERC Compliance Studies at Midwest ISO"
- "Prevention of Cascading Outages in Con Edison’s Network"
POM Suite – Real-Time

POM Suite - Real Time

POM-RT
Physical and Operational Margins

OPM-RT
Optimal Mitigation Measures

BOR-RT
Region of Stability Existence

TS-RT
Transient Stability
ROSE - Region of Stability Existence: PMU-Based Model

- POM-RT: Physical and Operational Margins
- OPM-RT: Optimal Mitigation Measures
- BOR-RT: Region of Stability Existence
2. Capabilities of OPtimal Mitigation Measures (OPM)
OPM Implementation

- OPM is implemented as a steady-state and transient stability application:
  - A steady-state tool that alleviates voltage stability, voltage and thermal violations
  - A transient stability analysis tool that alleviates transient stability violations
Determining Optimal Remedial Actions (System Adjustments)

- Fast, powerful and efficient remedial actions tool
- Automatically alleviates violations during massive AC contingency analysis
Capabilities of OPM

Works in two modes:
- Corrective actions
- Preventive actions

Relieves thermal, voltage and voltage stability violations:
- Determines the minimum actions needed to alleviate violations, based on user-specified priorities
- Mitigates base case violations
- Increases voltage stability margins
- Increases transfer capability
- Prevents cascading outages
Execution Time

Execution time on a stand-alone PC:

- 15,000-bus State Estimator case
- 1,155 contingencies
- 36 contingencies cause voltage and/or thermal violations
- AC contingency analysis – under 12 sec
- AC contingency analysis with OPM – under 32 sec
OPM Modes

Preventive actions:
- Identifies one set of measures which is effective for alleviating all post-contingency violations

Corrective actions:
- Identifies a set of corrective measures for each contingency causing violations

Three sets of OPM options may be set within one run for:
- N-0 contingencies
- N-1 contingencies
- N-2 contingencies
Remedial Actions Used in OPM

- Applies minimum amount of remedial actions based on a user-defined priority schedule

- Available remedial actions include:
  - Vsch - MVAr Dispatch
  - ULTC - Transformer Tap Change
  - PAR - Phase Shifter settings
  - SVD - Capacitor and Reactor Switching
  - Gen - MW Dispatch
  - Branch - Line Switching (In and Out)
            Switching Not Affected Lines
  - Load - Load Curtailment
  - CapPl - Optimal Capacitor, Reactor Placement and size
  - OpProc - Incorporation of effective measures previously identified by OPM
Alleviating Voltage/Thermal Constraints

- Determines the remedial actions based on a user-defined priority schedule
  - Uses optimization technique and sensitivity analysis

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Options:
- Unit Commitment
- Sorting
- Facilities: 32
- OPM Threshold, %: 5
- Mismatch Minimization
Branch Measure: Switching Not Affected Lines

- The option allows to switch lines in and out
- Allows a user to alleviate violations by switching not affected (i.e., non-overloaded) branches:
  - Automatically selects the lines that must be switched, in order to effectively alleviate the violations
Alleviating Voltage Stability

- Determines the remedial actions
  - Based on a user-defined priority schedule
  - Based on automatically identified priorities
3. Several Examples of Applications of OPM in Real-Time and Operations Environments
Region of Stability Existence (ROSE) at ISO NE: Real-Time

- ROSE uses PMU and SE data for on-line calculation and visualization of the current operating point and its proximity to the stability boundary.

- Operator is alarmed if the operating point and the boundary are moving towards each other.

- If the operating point and the boundary are moving towards each other, automatically identifies (recommends to the operator) minimal optimal preventive actions before the new SE case arrives and before the system collapse.

Figure p. 27, see http://ewh.ieee.org/reg/1/809/Litvinov.pdf.
Use of Remedial Actions in ROSE

- The effect of remedial actions on increasing the boundary for the limit case
- Using remedial actions to increase the region beyond the limit case
The Bridger West RAS

POM Workshop & User-group meeting
Los Angeles, CA (April 11-14, 2011)
New Remedial Action Scheme

- New Approach
- After a couple of unsuccessful false starts hired V & R for the development work for a methodology to use in developing setting parameters for the RAS.
- Plan to use POM & related tools to extract information to populate Arming Level & Scheduling Limits coefficients.
Features & Objectives of the new Bridger West RAS

- Replace existing 20+ year Remedial Action Scheme w/ new two completely redundant & independent systems. Each new system is made up of identical triple modular-redundant subsystems. (new RAS in service on 10/29/2009)
- Maximize Path OTC
  - Uses regression analysis to capture sensitivities to
    - Bridger MW & Mvar generation level
    - Neighboring path flows
- Minimize calls for Bridger unit tripping
  - Increase selectivity (amount of generation to be dropped is calculated based on system configuration, fault type & severity).
- Increased reliability
  - Meets WECC’s RASTF redundancy requirements
  - Very high availability numbers.
- Increase flexibility
  - Self adaptable to N-1, N-2 and other pre-determined system configurations
Run P-V Curve Analysis for flowgates in ATC System sensitive to voltage collapse. Establish operating limits during different construction phases.

1. EMS cases provided every “X” minutes
2. PSSE Planning Cases

If using real time cases to support Operations, verify the voltage contingencies identified by POM-OPM with AREVA Contingency Analysis Tool

Establish P-V Curve Analysis process for in Operations (for different flowgates that are subject to voltage collapse in ATC System)
Power Transfer Analysis and N-K Visualization Tool Indicator

To evaluate “X Interface” and to provide System Operators at ATC with guidance (proposed Reliability Limits) as to possible system conditions that would warrant close observation of the Interface flows to ensure system reliability. Identify plans inclusive of emergency generation redispatch (and load curtailment as a last resort) that may guide operators during emergency conditions.

Critical CTG Input List:
1. GEN 1
2. GEN 1 + 345 kV line
3. 345 kV line + 345 kV line …

User can benchmark results by using EMS Power Flow and simulate the power transfer manually. Results should be identical if same input conditions are used (e.g., power compensation etc)
Evaluate Real-Time System Reliability Software: Implementation at East Kentucky Power

- Software Demonstration
  - Evaluate the performance of “planning” software in a real-time environment

- EKPC’s Objectives
  - Reduce transmission constraint costs
  - Increase power transfer capability
  - Provide post-contingency remedial recommendations
  - Replace multiple planning software tools
  - Adopt as an operational tool
The Value of Speed

- Model reduction unnecessary
  - No need for smaller model for operations staff
- More thorough analysis
  - Complete n-1 contingency (20 minutes) on full model
- Model power transfers
  - Recommend actions to increase power transfers
- Quickly provides post-contingency results
  - Provides remedial actions
- Thorough line request analysis
  - No need to study the loss of particular n-1 facilities – evaluate all of them!
Conclusions

- Excellent software tool
  - Results matched in-house studies
  - Provides additional capabilities
  - Applications integrated into a single software platform

- Testing phase
  - Transmission planning
  - Power Delivery Operations
  - Likely to replace existing tools