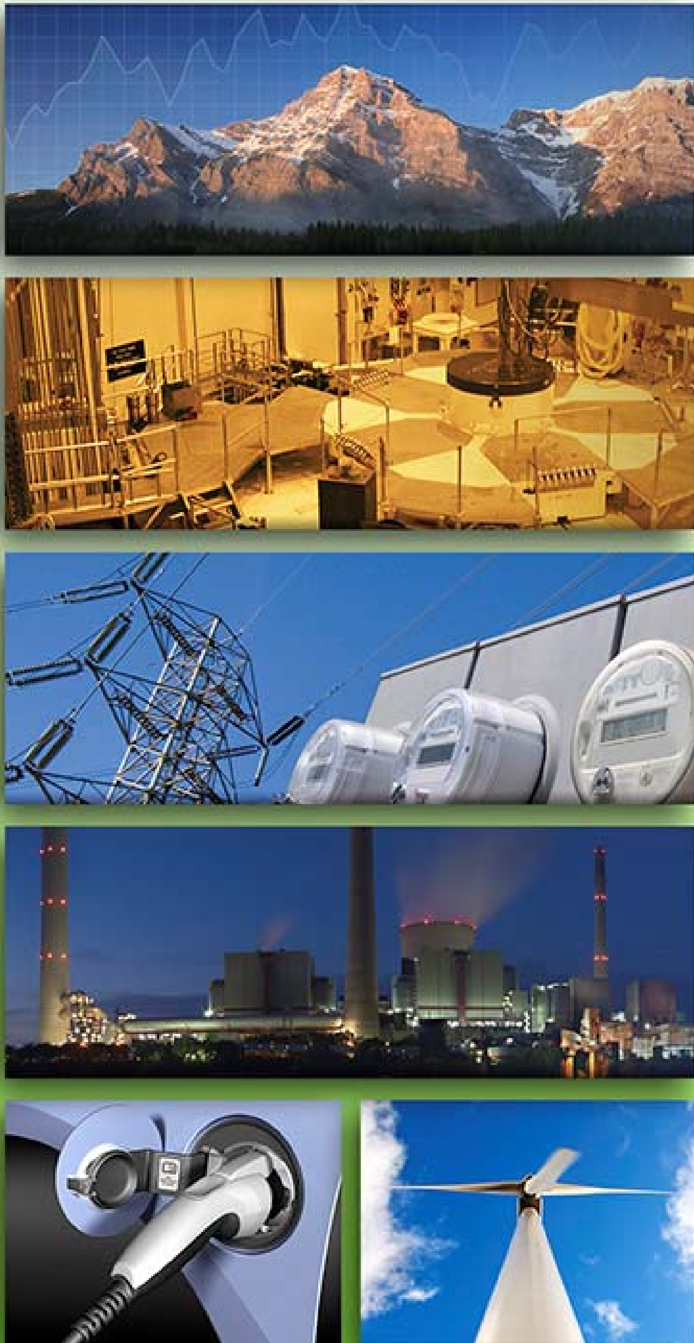

Summary of EPRI PQ/ADA Conference & Exposition Volt-VAR Control Workshop

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Event
IEEE PES 2010 General Meeting
Smart Distribution Working Group
Volt VAR Task Force

Date
Monday July 25, 2010

EPRI PQ/Smart Distribution Conference & Expo

Programs: Power Quality (1), Smart Distribution Research Areas (124), Distribution Systems (128), IntelliGrid (161), Electric Transportation (18), Efficient Distribution Systems (172B)

June 14 – 17, 2010

Fairmont Le Château Frontenac, Québec City, Canada

Volt-VAR Workshop

- Objectives:
  - *"explore current experience with the implementation of voltage and var control systems for voltage optimization"*
  - develop a starting point for a task force report from the IEEE Volt/Var Task Force under the Smart Distribution Working Group
- Agenda
  - Industry volt VAR Optimization Initiatives (Tom Rizy)
  - Approaches to Volt-VAR Control and Opt (Bob Uluski)
  - VVO Benefits and Challenges (Nokhum Markushevitz)
  - Case Study Presentations (10 utilities + 2 additional)
  - Related EPRI Initiatives (Mark McGranaghan)
- Attendee profile
  - Total Attendees: 57
  - Mix of Participants: 38 utilities, 11 vendors, 8 consultant/research/ academic
- Link to presentations

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Case Studies in Volt-VAR Control & Optimization

- American Electric Power
- Southern California Edison
- Hydro Quebec
- Duke Energy
- BC Hydro
- Snohomish PUD
- Southern Company
- United Illuminating Company
- EDF
- ESB Networks (Ireland)
- *Progress Energy (Carolinas)*
- *Xcel Energy*

Approach to VVC&O

Benefits

Challenges

Objectives for Volt-VAR Control

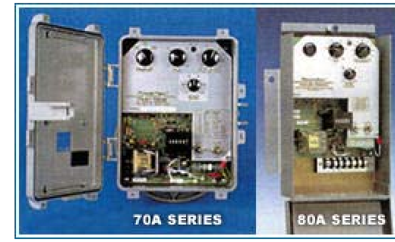
- Reduce peak customer demand
- Lower energy consumption (conservation)
- Reduce electrical losses (max efficiency)
  - Power factor improvement
- Voltage quality improvement - mitigate impact of rapid voltage changes (Flicker)
- Control of reactive power flow between DSO and TSO
- Relieve transmission congestion
- Integrate and optimize distributed generator output

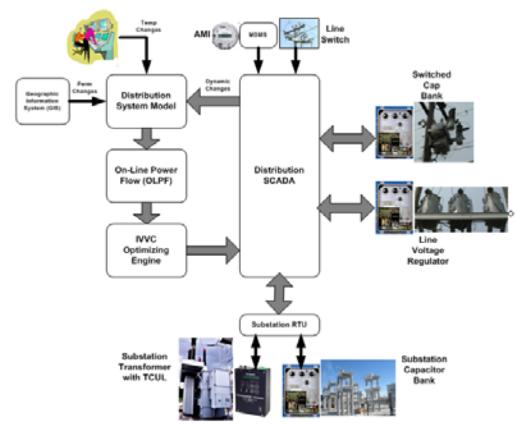
The three main objectives

Ability to ***predict*** results of Voltage Optimization is another key objective

Approaches to Volt VAR Control

- **Standalone** Voltage regulator and LTC controls with line drop compensation set to “end-of-line” voltage for CVR
- **On-Site Voltage Regulator** (OVR) for single location voltage regulation
- **“Rule-based” DA control** of capacitor banks and voltage regulators for CVR with/without voltage measurement feedback from end of line
- **“Distribution model based” voltage reduction** (CVR) running on DMS or “bolt-on” VVO application server
- **DMS (model based)** volt-VAR optimization (VVO)
- **“Adaptable”** voltage regulation (e.g. PCS Utilidata “AdatiVolt”, Cooper Power Systems)





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Need for Infrastructure Improvements

- **Feeder conditioning needed to "flatten" voltage profile** to maximize CVR benefits
- Addition of **fixed and switched capacitor banks**
- Feeder **re-configuration**
- Feeder **phase balancing**
- **Reconductoring**
- Replacement of electromechanical volt-VAR controllers with **Intelligent Electronic Devices (IEDs)**
- Addition of two way **communication facilities**
- Addition of **end-of-line (EOL) metering**

Benefits Achieved

- **CVR factor** for voltage reduction ranges from 0.65 to 0.7
- **Reduction of electrical demand** ranges from 1.5% to 2.1%
  - Cheap alternative to conventional generation
  - Reduction of total demand by 310 MW (eliminate need for two peak shaving CTs)
  - No carbon or emission offsets needed
- **Reduction of energy consumption** ranges from 1.3% - 2%
- Near **unity power factor**
- Provide **demand response** capabilities
- Decrease sub/feeder **overloading**
- **Reduced** High and Low voltage **complaints**
- Improve Customer voltage quality (**less flicker**).
- Increase customer **end-use appliance life** by 15%.
- **Lower Customer Bills** $16.50/yr
  - Recover like other conservation measures

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Challenges

- **<u>Technical Challenges</u>**
  - Lack of communication facilities for field devices
  - Availability of medium voltage and low voltage sensors
  - Three phase switching decisions based on single phase monitoring
    - Problems with voltage imbalance
  - Instantaneous secondary readings at customer meters vary too much to be used for primary voltage control
  - Lack of coordination with customer initiated voltage reduction
  - Modeling errors for model based solutions
  - VVO Impact on transmission system
  - Vendor solutions for VVC are still evolving

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Challenges

- **Resources**
  - Considerable effort needed to keep system running - 5% O&M costs per year
  - Company resource constraints
    - Lack of trained technical people
    - Significant change management training needed
- **Financial/Regulatory**
  - Determining appropriate regulatory recovery strategy
  - Understanding how technical benefits translate into financial benefits
  - Inability to predict benefits in advance
  - Not easy to quantify benefits

Next Steps

- Modeling/simulation of approaches to volt-VAR optimization
- Development of accurate customer/load models for voltage optimization
- Related effort - DMS Interest Group

Questions?

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"Straw Man" Terminology for Volt-VAR Control & Optimization

- **Standalone Volt-VAR Control**
  - Use of capacitor banks, load tap changers, and voltage regulators equipped with standalone, non-communicating controllers to
    - Maintain feeder voltage within the acceptable range as defined by ANSI C841.-1995
    - Improve power factor at capacitor bank locations
    - Independent (non-coordinated) operation of cap banks, voltage regulators, and LTCs
- **SCADA "Rule-Based" Volt-VAR Control**
  - Cap banks, LTCs, and Voltage regulators remotely monitored and controlled by SCADA system
    - Settings of capacitor banks, LTCs, and voltage regulators controlled by distribution SCADA system based on real-time substation and field measurements
    - Setting control logic usually based on fixed set of "rules" ("if A then do B")
    - Control of capacitor banks handled by one set of rules; voltage regulators handled by second set of rules (no integration between systems) (independent, non-coordinated control scheme)

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"Straw Man" Terminology for Volt-VAR Control & Optimization

- **Voltage Reduction**
  - Control scheme that modifies the settings of capacitor banks, load tap changers, and voltage regulators to maintain feeder voltage within the lower half of the acceptable range as defined by ANSI C841.-1995
  - Commonly referred to as Conservation Voltage Reduction
  - May involve issuing control commands to "flatten" the voltage profile to maximize benefits achieved with voltage reduction
  - May be rule-based, model based, or "auto adaptive"
- **Volt-VAR Optimization (VVO)**
  - Control scheme that modifies the settings of capacitor bank controllers, LTC controllers, and voltage regulators to achieve one or more utility specified objective functions (reduce demand, lower losses, reduce energy consumption, or combination) to optimize system performance
  - Setting control logic usually based on dynamic model of the distribution system

"Straw Man" Terminology for Volt-VAR Control & Optimization

- **Dynamic Volt-VAR Control (DVVC)**
  - Control scheme for responding to very short duration voltage fluctuations that are commonly associated with renewable distributed energy resources
  - DVVC uses fast acting controllers, distribution static VAR compensators, inverters, etc. for managing these fluctuations