Agenda

• Volt/VAR Optimization Overview

• Technology Implementations

• Industry and DTE Experience
Volt/VAR Optimization Summary

- Volt/VAR Optimization (VVO) is a tool to dynamically adjust the distribution system to reduce system losses and minimize demand.

- Industry experience with Volt/VAR Optimization shows 1.5%-3% demand reduction possible.

- Volt/VAR Optimization does not require engagement from customers to achieve efficiencies; technology is implemented at system level.

- Amount of benefit is related to load types, with maximum benefit for constant impedance loads (i.e. incandescent light bulb) and lesser benefit for constant power loads (i.e. LED, CFL).
Distribution loading is influenced by system voltage

- All loads follow Ohm’s law, but components can be designed differently

- **Types of Loads:**
  - **Constant Impedance:** Resistance unchanged, results in variable power from variable voltage. (i.e. incandescent light bulb)
  - **Constant Current:** Resistance adjusts to voltage, results in variable power with different characteristic than constant impedance loads. (Very few loads are constant current)
  - **Constant Power:** Resistance adjusts to voltage, results in variable current but constant power. (i.e. CFL, LED)

- Table Source: IEEE Spectrum, October 2010
Volt/VAR Optimization uses load characteristics to achieve various objectives

- Conservation Voltage Reduction (CVR) mode
  - Energy efficiency at system level

- Peak Shaving mode
  - Reduction of system capacity
  - Less capacity needs means less power generation needs

- Power Quality Correction
  - Correct system voltage in real-time
Typical Distribution Circuit

- Typically, voltage level is highest at substation, lowest near the end of circuit
- Several solutions can be used to optimize the voltage profile across the circuit
  - Reconductoring changes system impedance (not cost effective)
  - Capacitors inject reactive support
  - Substation load tap changer and line regulators correct voltage without correcting losses
System Requirements for Volt/VAR Optimization

- Engineering solution needed for each circuit to realize benefits of dynamic voltage optimization
- Solution will use combination of alternatives
  - Transformer LTC
  - Line Regulators
  - Additional Capacitors
  - Wire replacement
  - *All devices require SCADA control

Example (3 circuits)
- 3 capacitors = $65k
- 2 line regulators = $85k
- 1 LTC Control = $15k
- Total cost = $165k

Expected Demand Benefits:
- 0.3 MW Peak Reduction
- 3,000 MWHr 3 year efficiency
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Centralized Volt/VAR Optimization Configuration

**Pros**
- Utilize existing DMS system model
- Buy logic system once, reduces incremental cost for expansion

**Cons**
- Requires high quality engineering model
- Relies heavily on centralized systems

Decentralized Volt/VAR Optimization Configuration

Pros
- Heuristics can be applied for self learning systems
- Reduce reliance on single logic point

Cons
- Logic controller required at each substation
- Configuration and maintenance of all controllers

Edge of Network Volt/VAR Optimization

**Pros**
- Granular optimization through Volt/VAR device at each service transformer
- More insight into distribution secondary

**Cons**
- Installation may be costly

*Image Source: Varentec report “Dynamic Grid Edge Control”*
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DTE’s centralized Volt/VAR Optimization Pilots

- Supervisory Control and Data Acquisition (SCADA) integrated with Distribution Management System (DMS).

- Distribution model allows for an accurate prediction of system loss and demand reductions possible.

- DTE’s DMS is capable of continuously analyzing system status and power flow to operate field devices.

- System demand reduction pilots are still ongoing at DTE.
Industry results

• Typical demand reductions in 1.5%-3% range

• Demand reduction can be as high as 4% on select circuits but is not common

• To realize the benefits above, most utilities have installed much of the required equipment and can implement relatively inexpensively

• Utilities typically verify VVO in controlled pilots to measure benefits before larger implementations
Lessons Learned

• System upgrades required vary by utility, based on existing equipment

• Demand benefits vary greatly by circuit

• Technology choice depends on existing assets and objective for Volt/VAR Optimization

• Utilities have been implementing Volt/VAR Optimization based on corporate strategy, system design, and cost/benefit