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Designed to seamlessly consolidate functions, Relion relays are smarter, more flexible and more adaptable. Easy to integrate and with an extensive function library, the Relion family of protection and control delivers advanced functionality and improved performance.

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ABB Protective Relay School Webinar Series

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ABB Protective Relay School Webinar Series

Volt-VAR Optimization

Chris Pierce

December 10, 2013

Presenter

Chris Pierce

- Chris graduated from Ohio University, with Bachelors in Electrical Engineering and The Ohio State University, with a Master of Business Administration.
- He began his career in the electric utility industry in a consulting role with Buckeye Power, Inc. out of Columbus, OH in 2002.
- In 2005, he graduated with his BSEE and accepted a position as a Protection & Control Engineer at POWER Engineers, Inc. in St. Louis, MO.
- In 2008, he joined American Electric Power in Columbus where he help multiple positions, including Protection and Control Engineer in Station Projects Engineering, Lead Engineer supporting distribution automation for Grid Management Deployment, and Supervisor of Planning & Engineering for Protection & Control Asset Engineering.
- Chris is currently a “Substation Automation Systems Architect” for “Substation Automation Systems” in ABB for the North America Region.

Learning objectives

- Business Case
- Volt-Var Optimization Theory
  - Conservation Voltage Reduction
  - Power Factor Correction
- Implementation Concepts
  - Project phasing and considerations
  - Simple VVO Example
- System Integration/Architecture

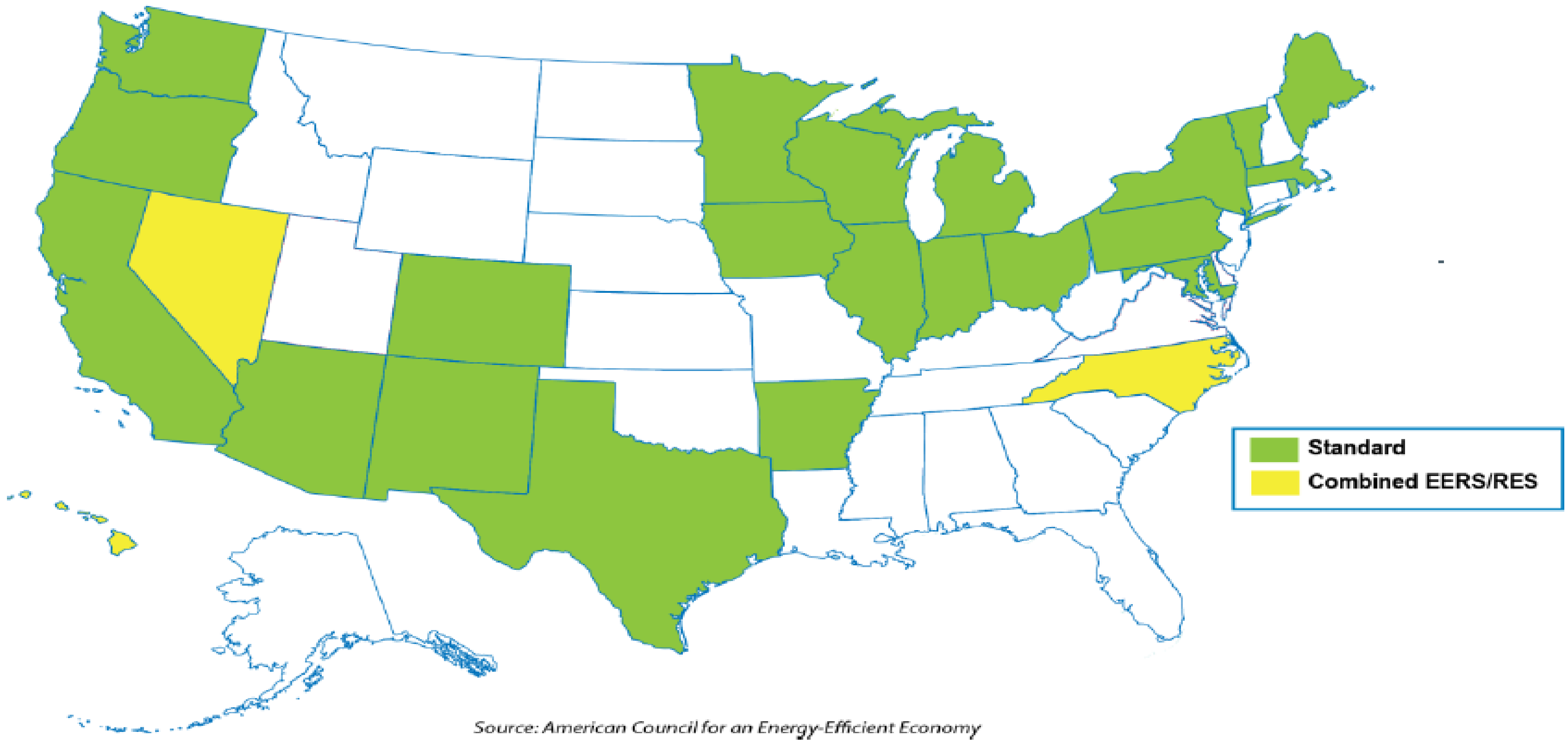
Key acronyms

- VVO – Volt-Var Optimization
- VVC – Volt-Var Control
- CVR – Conservation Voltage Reduction
- CVRf – CVR Factor
- M&V – Measurement & Verification
- EOL – End of Line (Voltage Monitoring Point)
- SCADA – Supervisory Control and Data Acquisition
- DMS – Distribution Management System
- IED – Intelligent Electronic Device
- RTU – Remote Terminal Unit

Business case overview

- Utilities can apply CVR for short periods of time to reduce peak demand and/or to reduce capacity payments for those distribution companies that are billed on the basis of their maximum monthly peak demand (2012 DOE Report)
- 25 States with Energy Efficiency Resource Standards (EERS)
- Optimizing power delivery on the distribution system can reduce energy (kWh) and demand (kW) to serve customers.
  - Many loads (including motors) actually function more efficiently with reduced applied voltage than when operated at (or above) system base voltage (eg 120V secondary)
- Public power entities are naturally incentivized to deliver power to customers at least cost, including the more efficient delivery of power.
- VVO systems optimize delivery voltage through CVR on a closed loop system, ensuring customers are receiving the lowest allowable voltage within ANSI C84.1 limits.
- VVO systems correct power factor is corrected at a central level to maximize capital investment benefit.
- VVO systems can leverage benefits without any customer interface!

Energy Efficiency Resource Standards (EERS)
Policy approaches by state (as of July 2013)

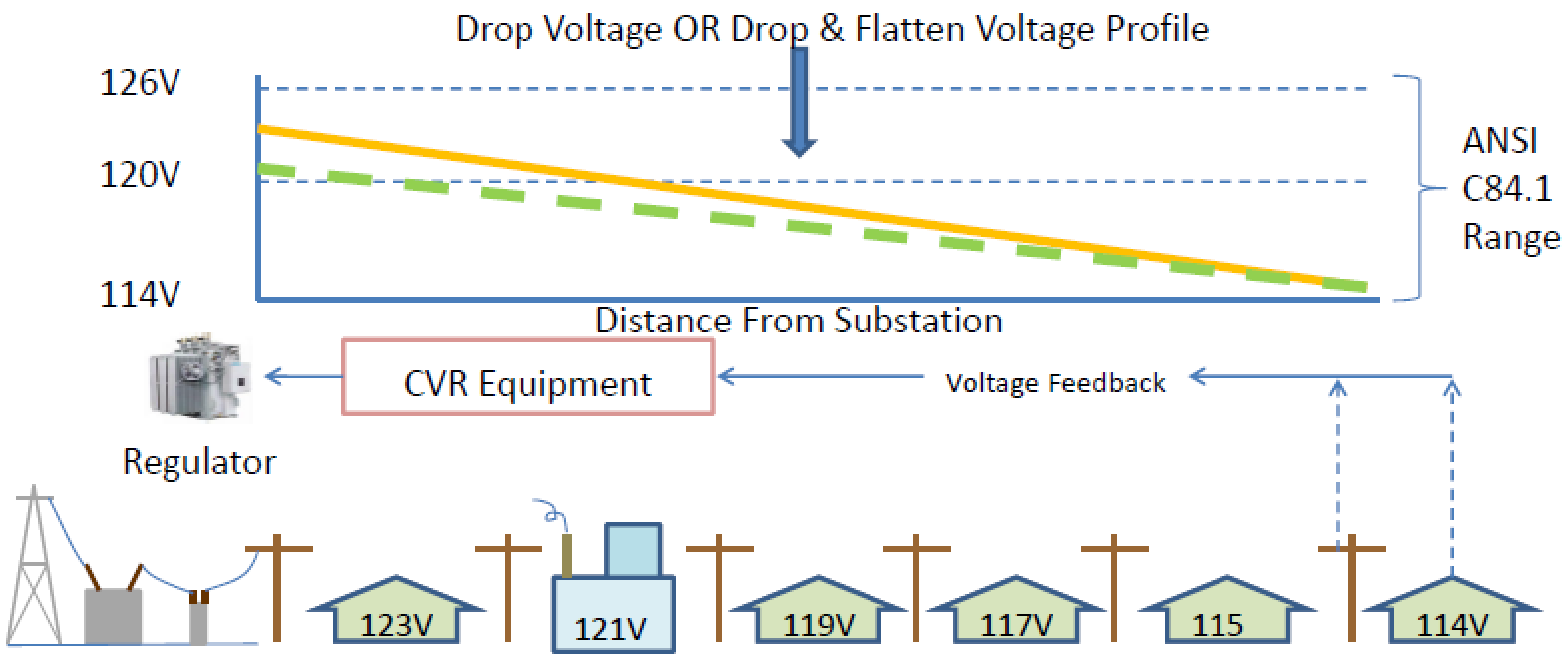


Conservation Voltage Reduction (CVR)

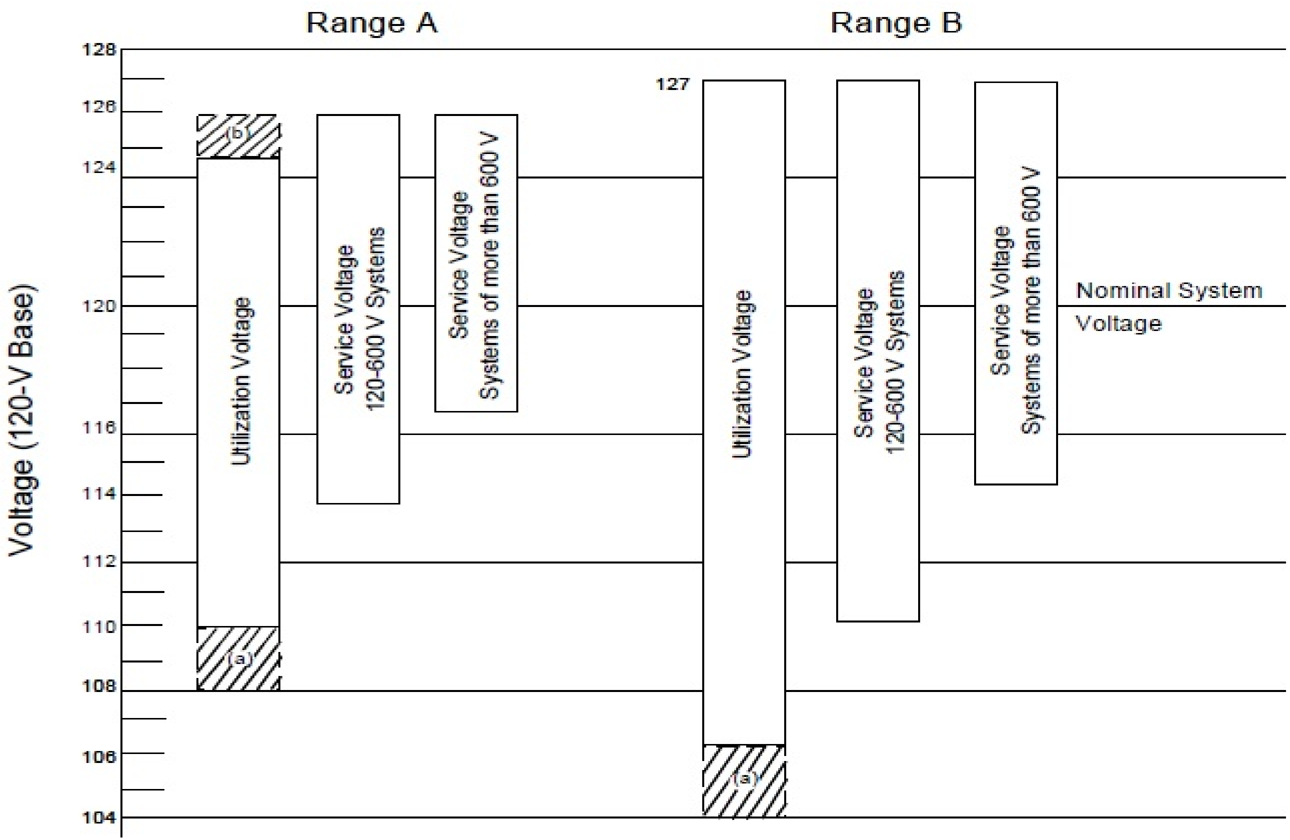
- Studies dating back to the 1980s (Effects of Reduced Voltage on the Operation and Efficiency of Electric Loads, EPRI, September 1981) have shown that small reductions in distribution voltage can reduce electricity demand from customer equipment and save energy. This has become known as "Conservation Voltage Reduction (CVR)".
- Utilities are regularly seeing energy and demand reduction of 3% or more with CVRf between .7 and 1.0 (or greater).
- CVR response is dependent upon the type of loads on the feeder as well as general feeder characteristics.
- Most heavily loaded feeders should be targeted first for the most "bang for your buck".

Conservation Voltage Reduction (CVR)
Theory

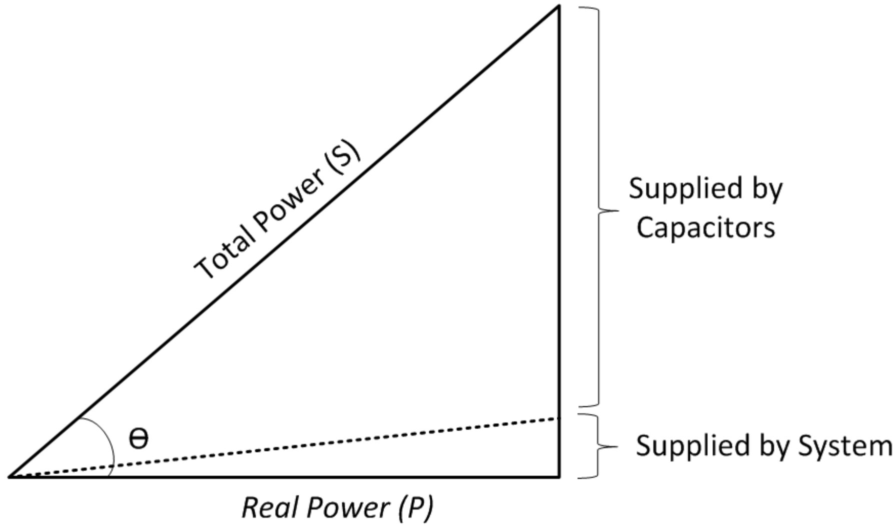
$$CVR\ Factor = \frac{\%\ demand\ reduction}{\%\ voltage\ reduction}$$



Conservation Voltage Reduction (CVR)
ANSI C84.1 Voltage Limits

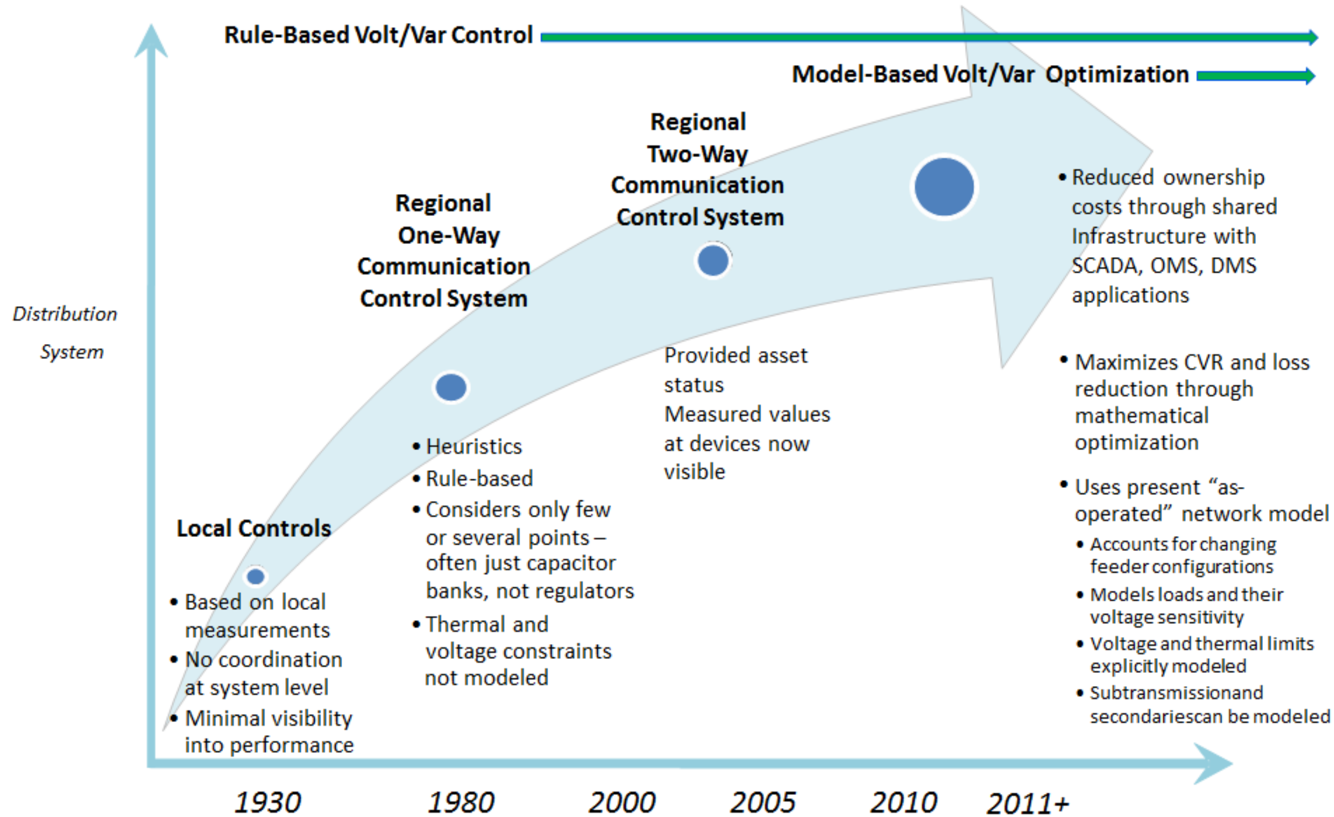


Power Factor Correction
Theory



- Shunt capacitors can provide much of the reactive power required on a distribution circuit, reducing the total power requirements
- Optimizing power factor (real power as a ratio of total power) to unity reduces distribution system losses, minimizing capital investment requirements

VVO system implementation
Automation system concepts



Volt-Var Optimization (VVO)
Technical considerations

- "Traditional" power factor correction solutions are able to solve simple power factor problems at local levels
  - How do you know the capacitor bank is online and functioning properly?
  - How do you know the overall power factor is being optimally corrected?
- "Traditional" CVR correction techniques involve lowering LTC/regulator tap positions at feeder/bus heads to implement demand response
  - How do you know the utilization/service voltages are within acceptable ANSI C84.1 limits?
  - How do you know the voltage level has been optimized without closed loop voltage monitoring on the system?
- "Centralized" VVO automation applications can help solve all of these challenges, while providing better optimization at a system wide level.

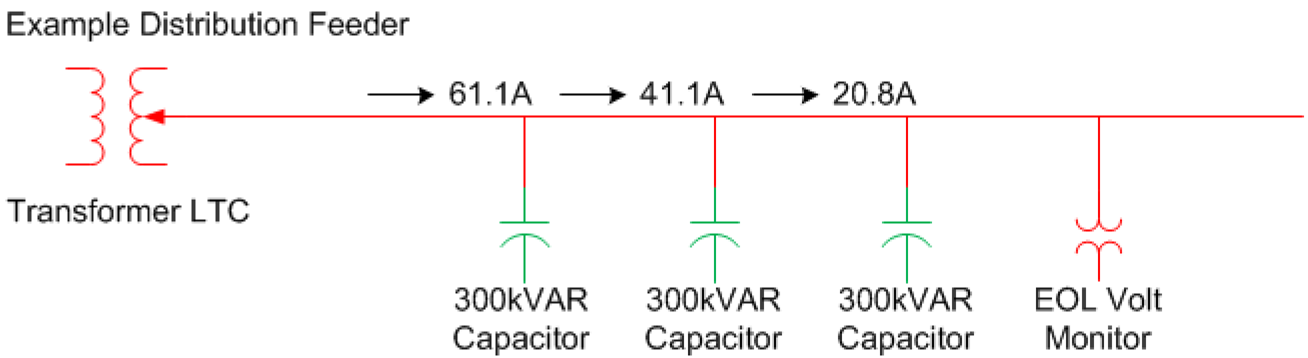
VVO system implementation
System components

- Automation application
    - Software (eg ABB MicroSCADA Pro)
    - Hardware
        - For substation based applications this should be a station hardened computer (eg ABB MicroSCADA Pro SYS600C)
        - For sub-enterprise/enterprise based applications this should be a more traditional server
- Distribution circuit components
    - Equipment (cap banks, reg banks, LTCs, reclosers, EOL sensors, etc.)
    - Intelligent electronic devices (IEDs)
        - These need to communicate via standard open protocols such as DNP3!
- Telecommunications equipment
    - Typically wireless radios for telemetry to distribution circuit devices
    - Fiber can also be integrated where feasible, such as station backhaul

VVO system implementation
Project steps

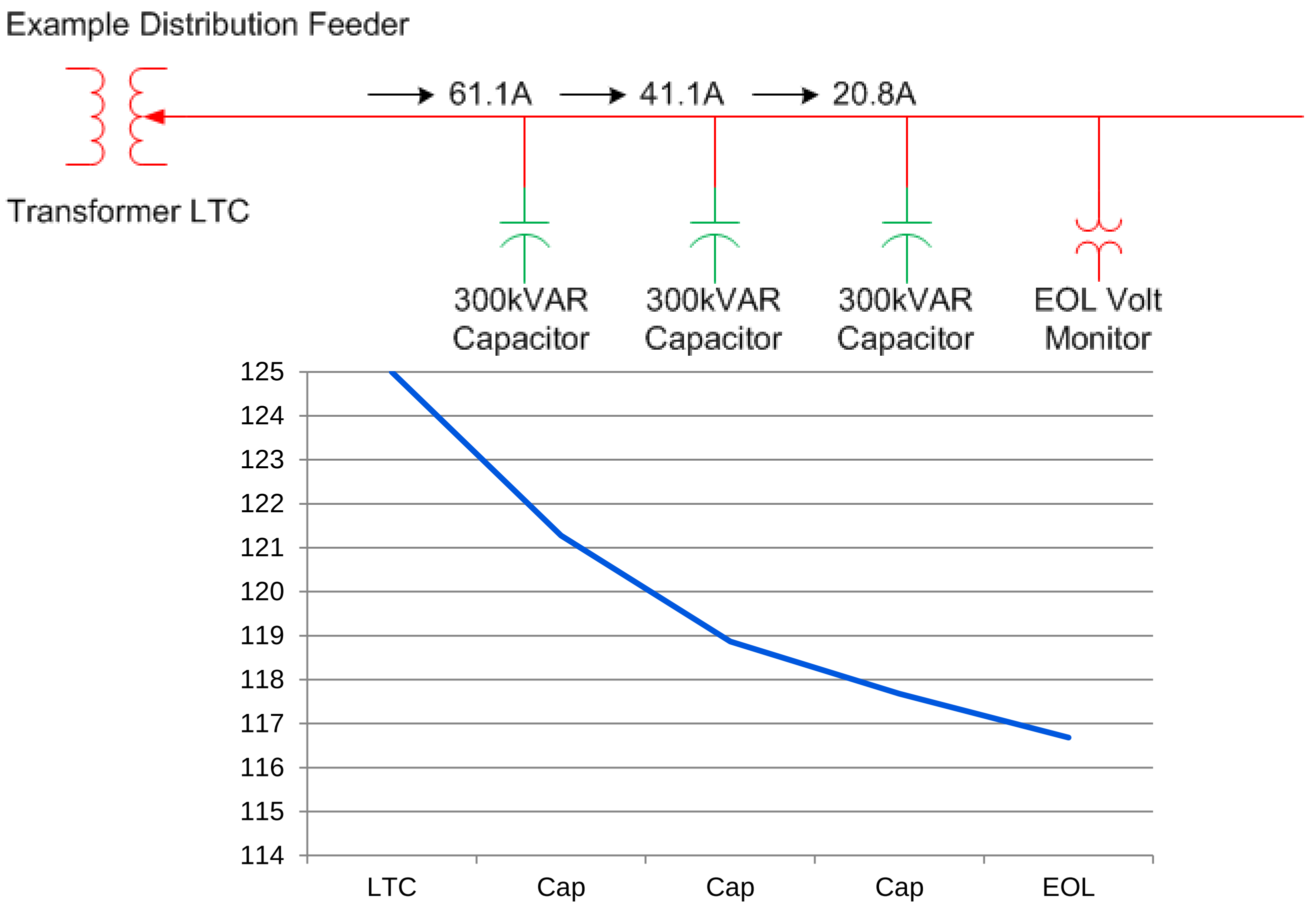
- Planning
  - Model circuits to determine optimum equipment layout and investment requirements based upon project budget
  - Identify “bellweather” EOL monitoring locations to ensure ANSI C84.1 compliance
  - Telecommunications site survey for any wireless infrastructure
- Engineering/Procurement
  - Circuit engineering for new equipment (no different than “traditional” engineering)
  - System engineering for automation application (VVO)
  - Telecommunications engineering for wired/wireless infrastructure
- Integration (may be associated with factory acceptance testing)
  - Ensure all distribution/telecommunications/automation applications function together as one congenial system!
- Testing/Commissioining (typically associated with site acceptance testing)

Simple feeder scenario
Base case

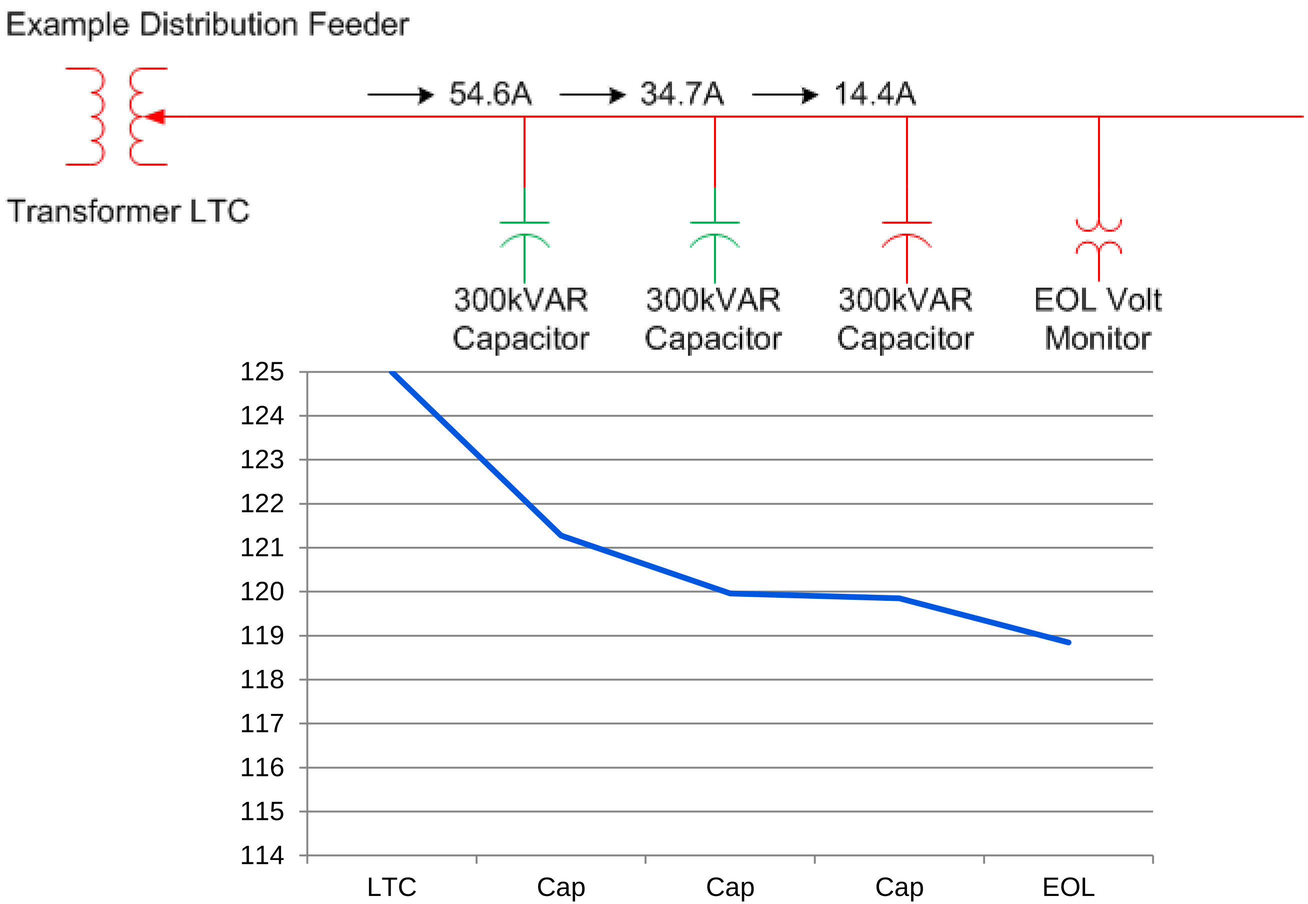


- 12.47kV feeder w/ LTC on transformer regulating to 125V secondary at feeder head (120V base)
- Base power factor of .7 with no power factor correction implemented
- Line impedance of .4 + j.6 ohms per mile, each line section is 5 miles
  - .4 ohms is the “real” resistance, j.6 ohms is the “imaginary” reactance
- CVRf = 1.0 (1% drop in demand for each 1% drop in voltage)

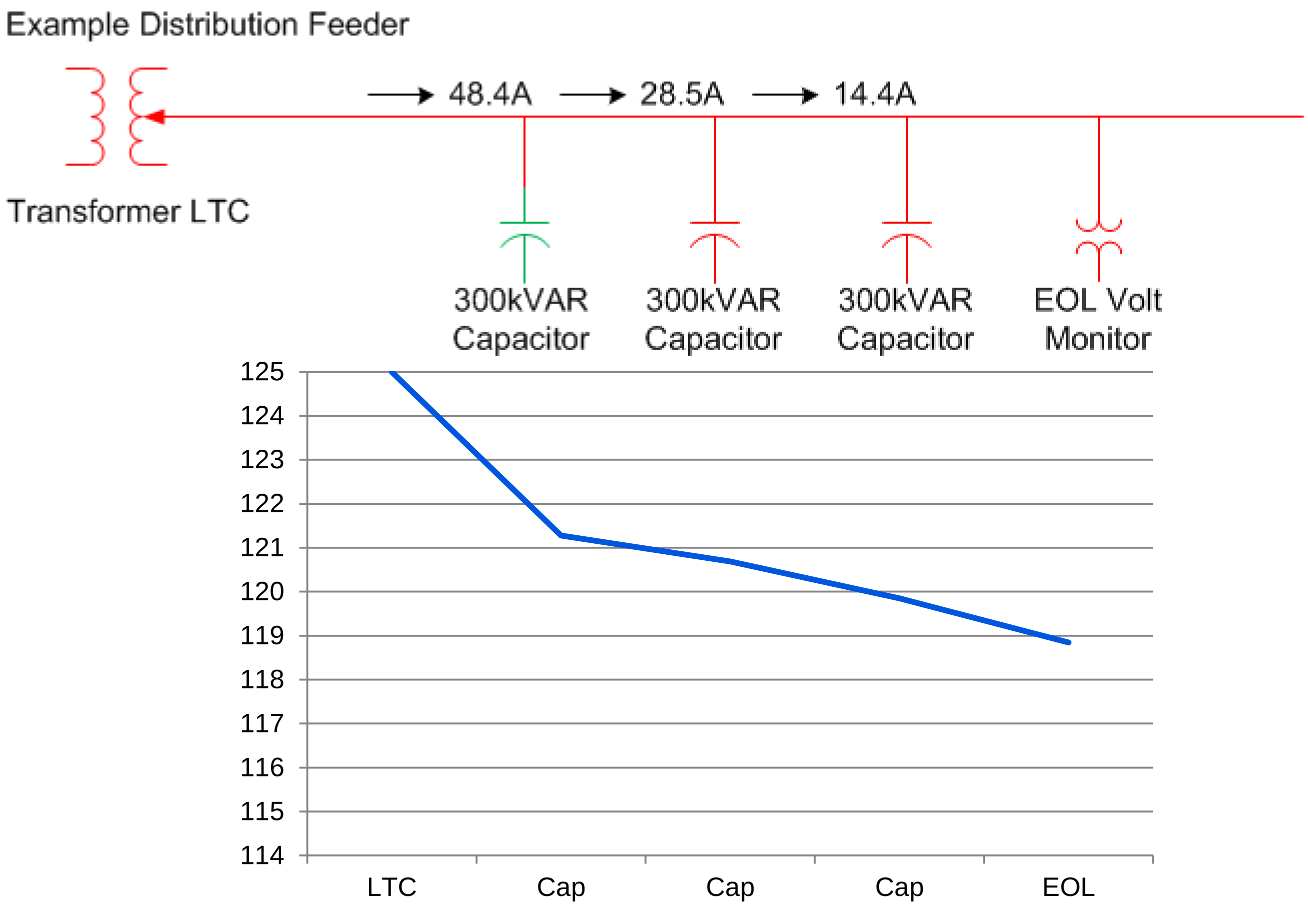
Simple feeder scenario
Base case



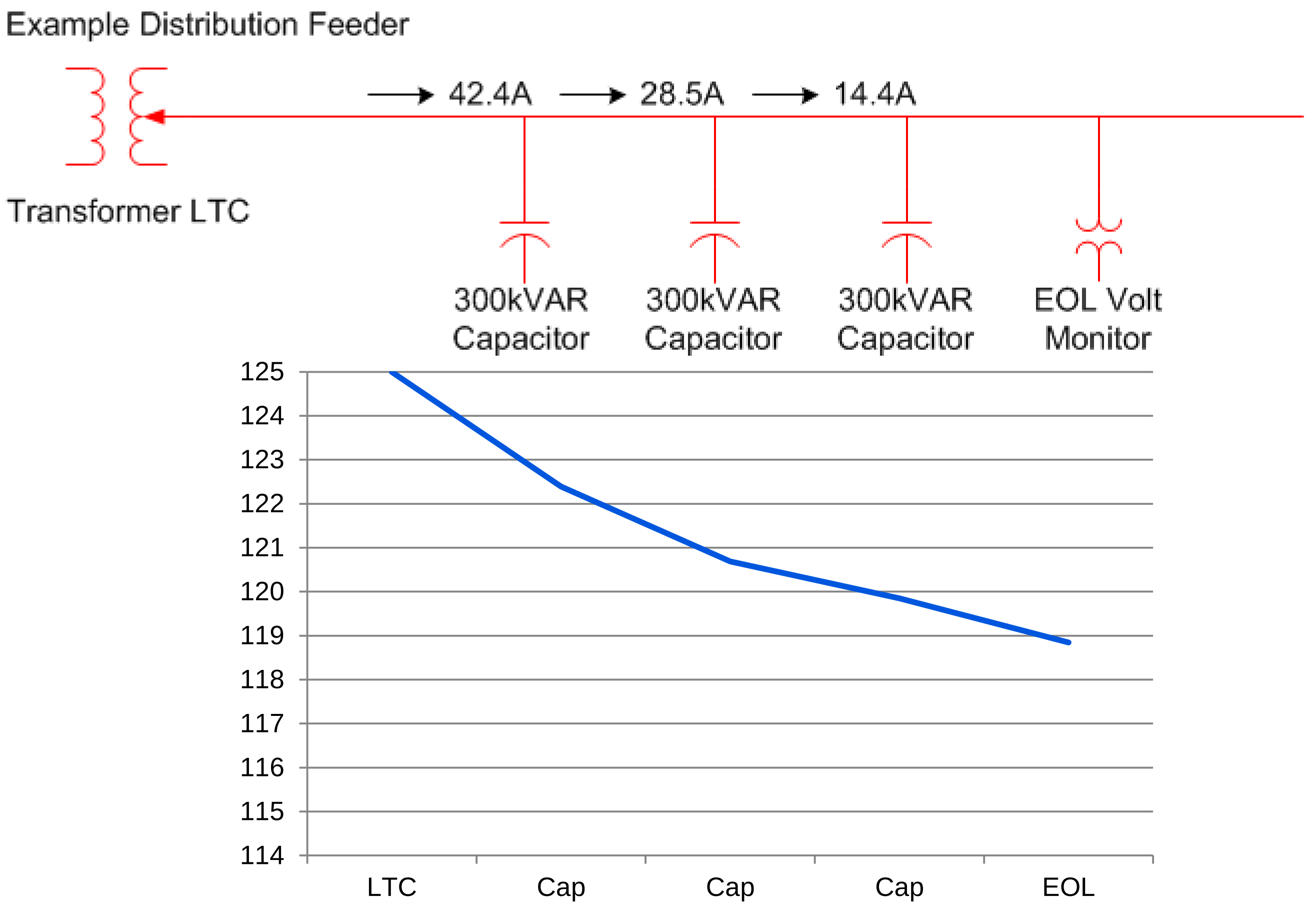
Simple feeder scenario
Switch in capacitor bank 1



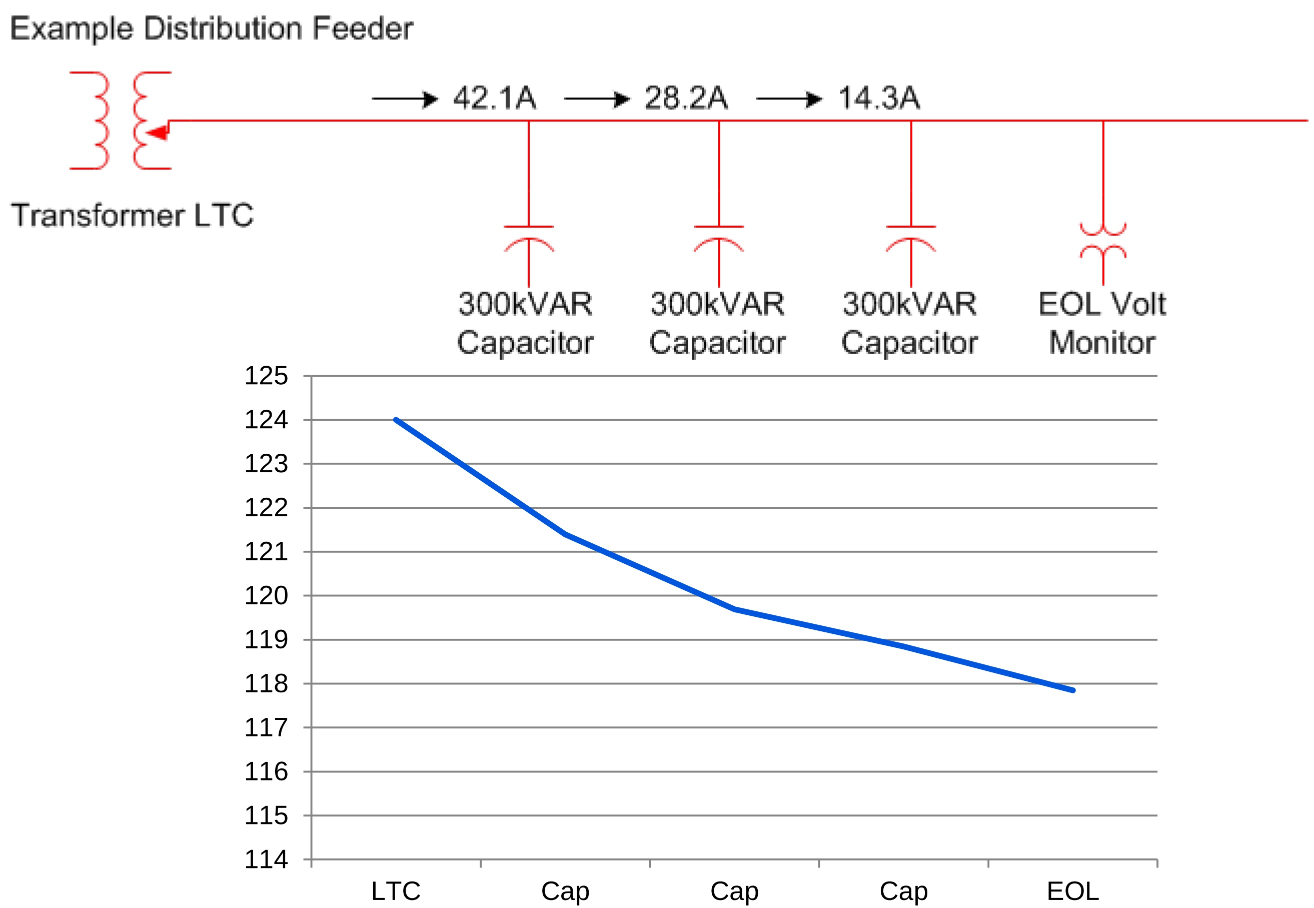
Simple feeder scenario
Switch in capacitor bank 2



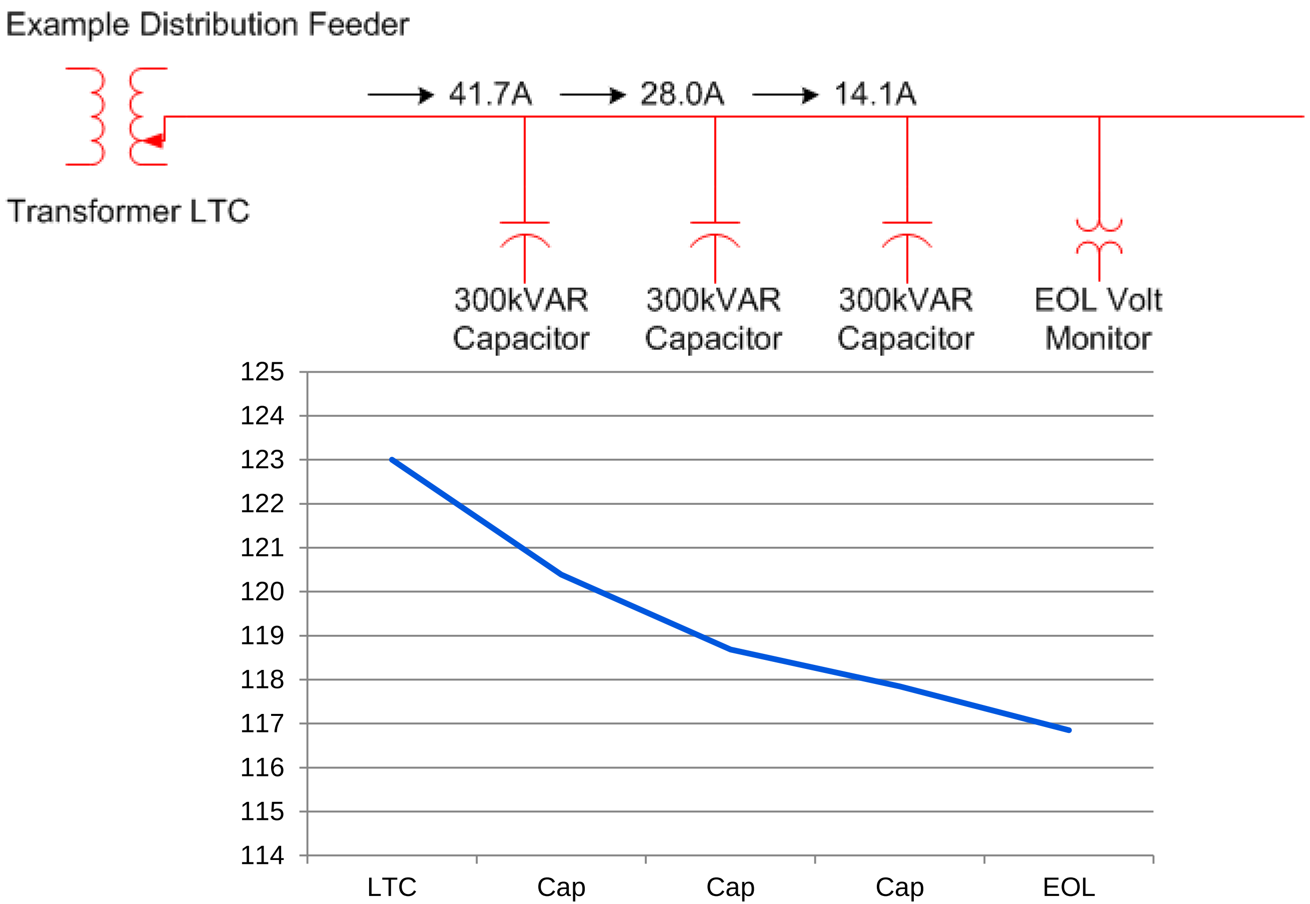
Simple feeder scenario
Switch in capacitor bank 3



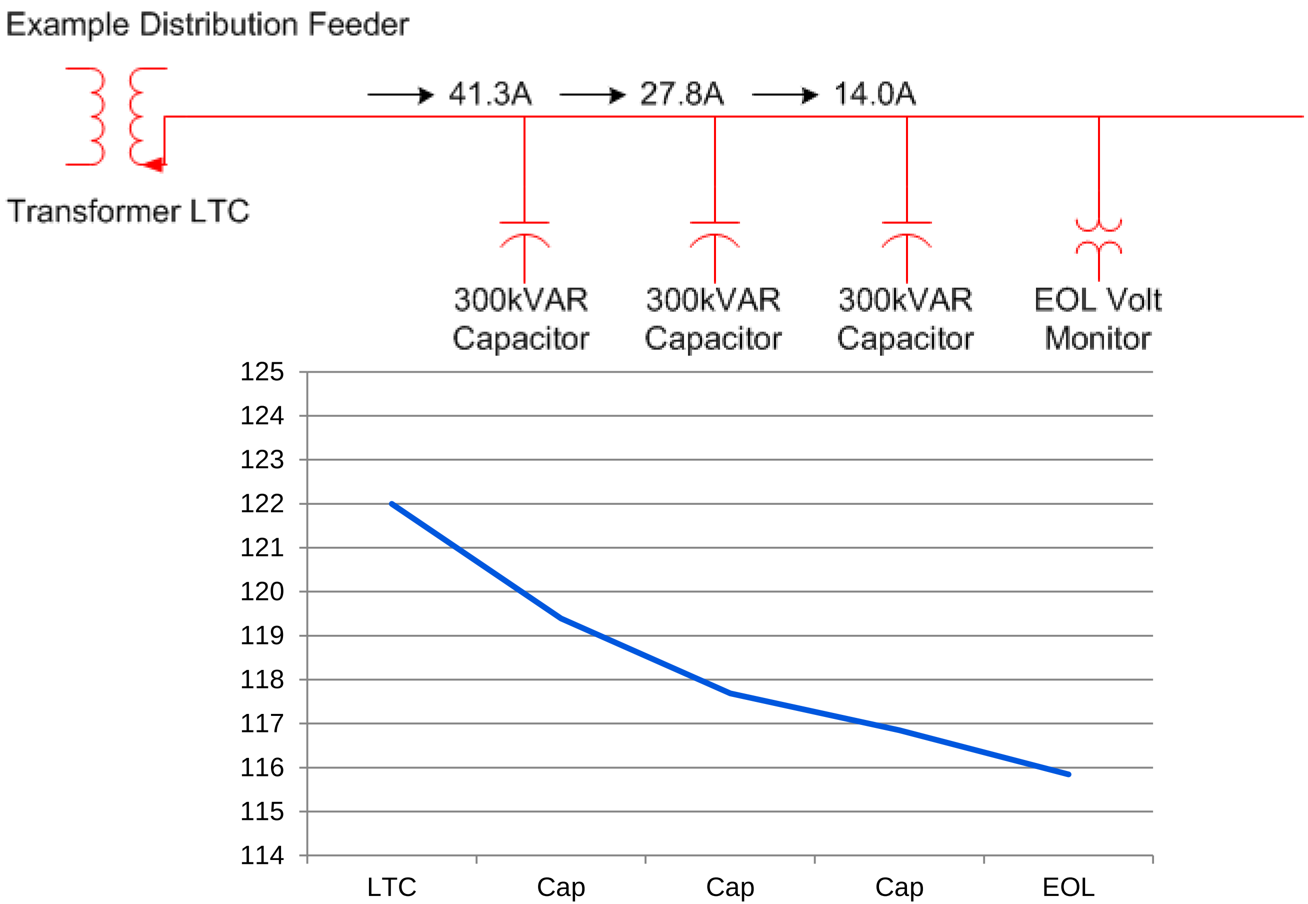
Simple feeder scenario
LTC lower 1 LTC tap position



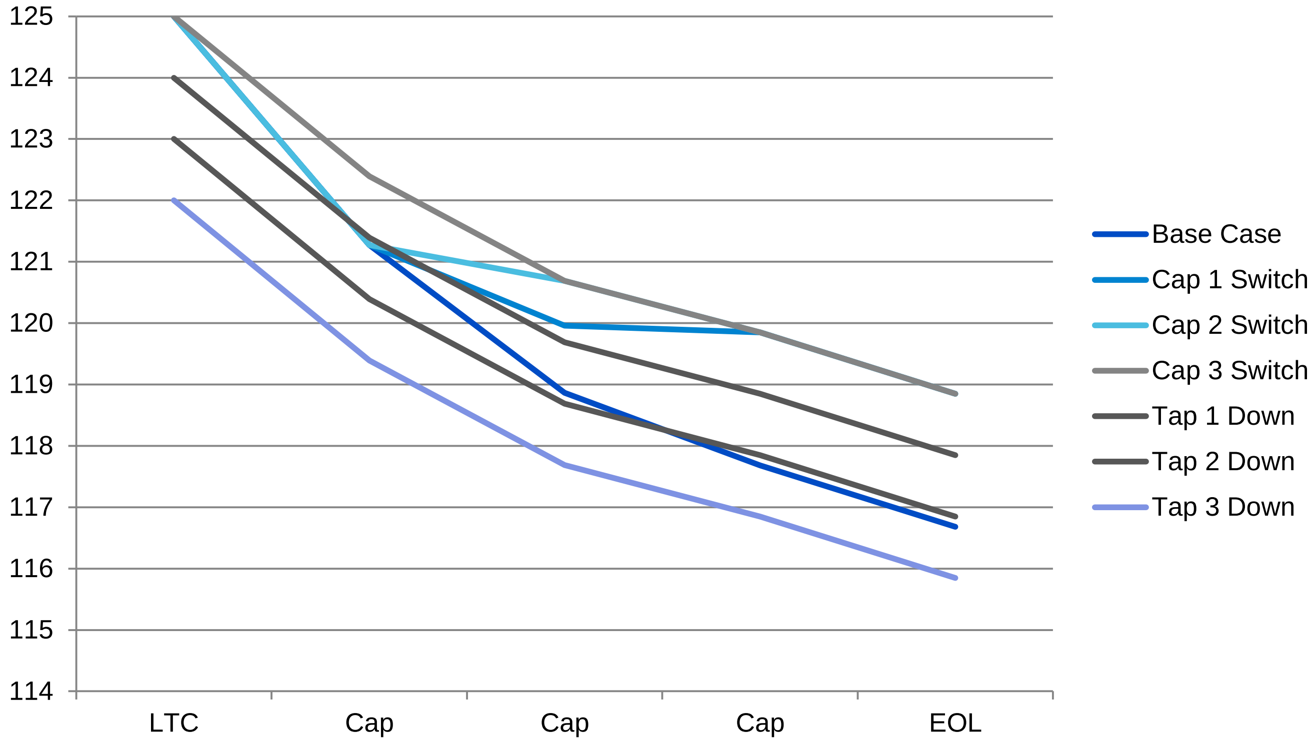
Simple feeder scenario
LTC lower 1 LTC tap position



Simple feeder scenario
LTC lower 1 LTC tap position



Simple feeder scenario
Case comparison



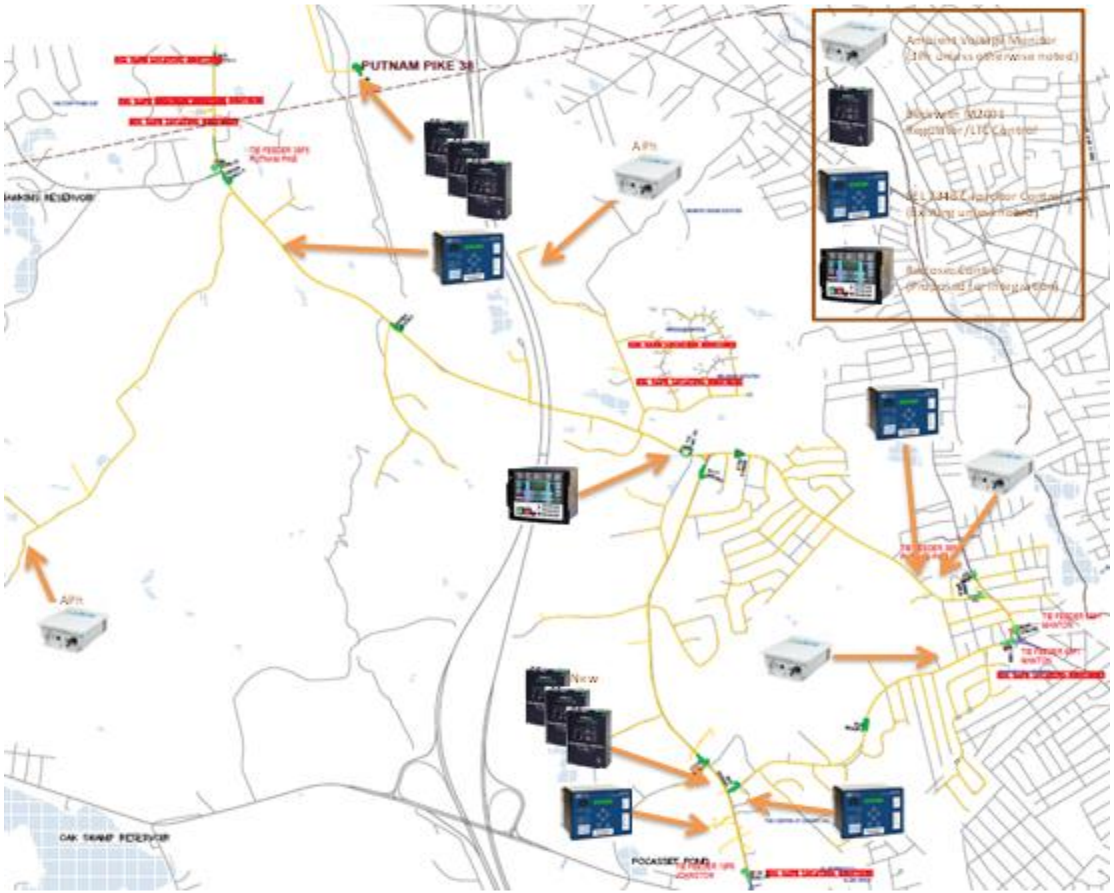
Volt-Var Optimization (VVO)
Example results & takeaways

- Feeder power factor corrected from .7 to near unity
- Feeder current reduced from 61 A/phase to 43 A/phase
- Feeder load reduced from 1.3MVA to .9MVA (33%)
  - 2.5% demand reduction from CVR (assume CVRf of 1%)
- Majority of savings due to reduction in reactive power requirements provided by utilizing shunt capacitors for power factor correction
- Loss reduction also evident through reduced line currents

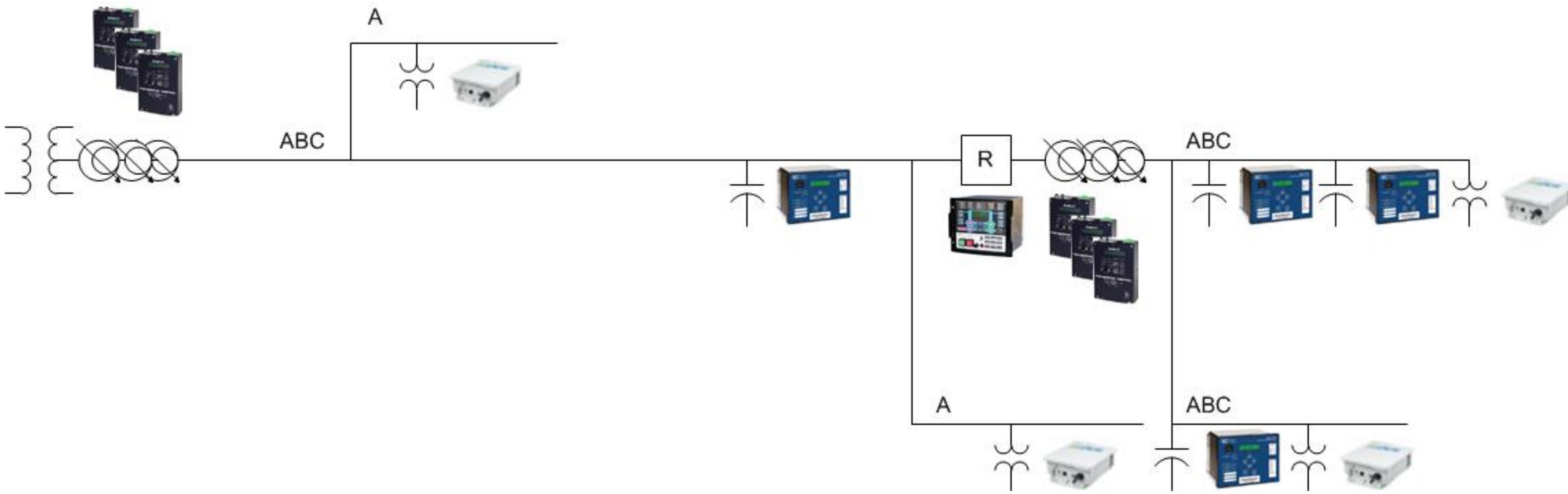
Volt-Var Optimization (VVO)
Example results & takeaways

- Obviously, power factor correction provides the most “bang for your buck”
  - Chances are, utilities already have installed capacitor banks operating locally so some of this benefit is already achieved
  - Implementing VVO presents the opportunity to revisit the power factor correction studies from a centralized standpoint
  - Ancillary benefit of VVO: integrating telecommunications network with IEDs facilitates distribution SCADA system operational efficiency (keep your cap banks online and functioning properly!)
- Capacitor banks help to flatten the load profile, allowing true voltage optimization
- CVR benefits seem small in comparison to power factor correction; however, when combined across multiple feeders/stations the benefits are rather large

Example VVO geographical circuit layout
Multi-vendor integration

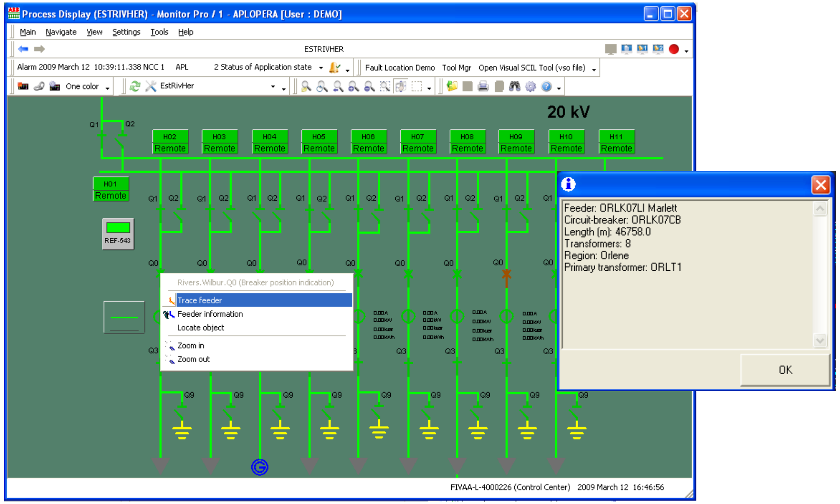


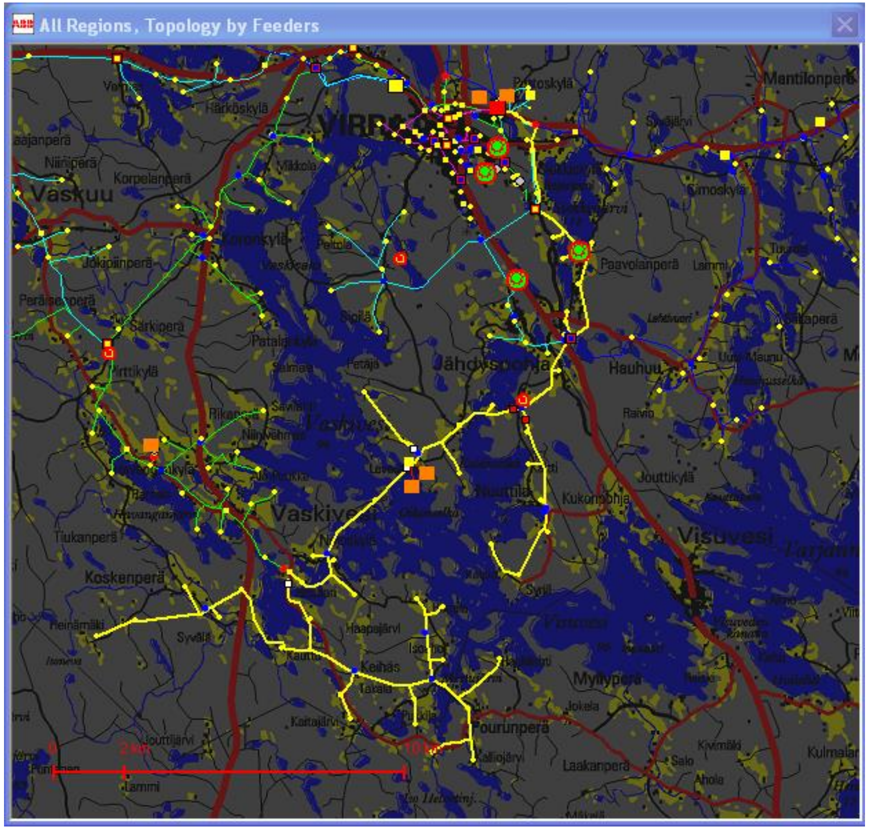
Example VVO one-line circuit representation
Multi-vendor integration



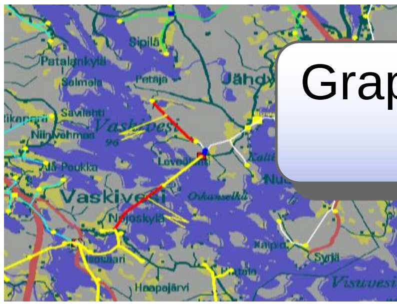
VVO geographical interface integration

- One-line integration
- Geographical representation
- Integrate additional automation application functions (SCADA/DMS/FDIR etc.)





Additional automation application synergies

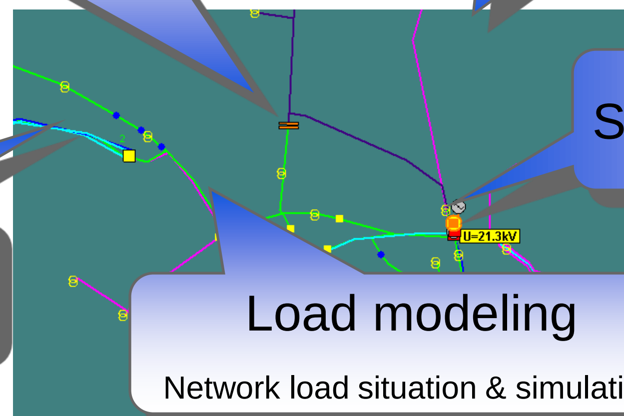


Graphical Network Maps

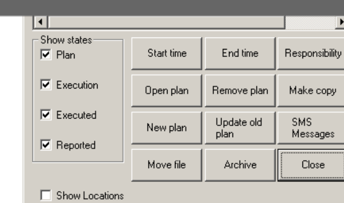
Decluttering

Field Crew Management

Field crew location and movement

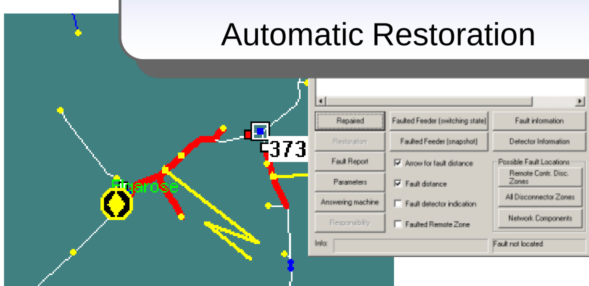


Switch Plan Management



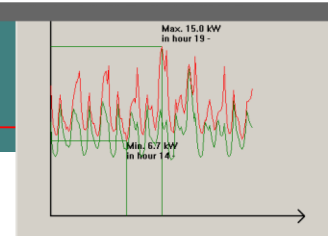
Fault Location

Automatic Restoration

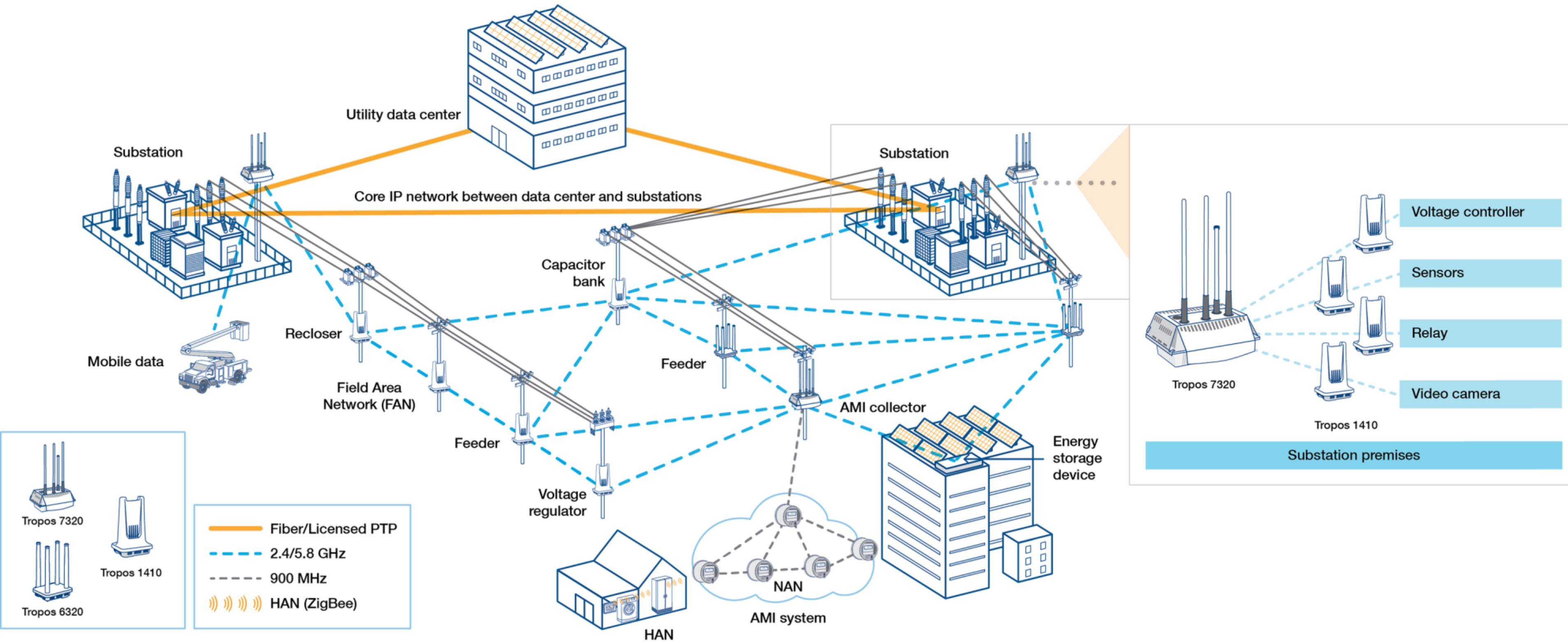


Load modeling

Network load situation & simulation



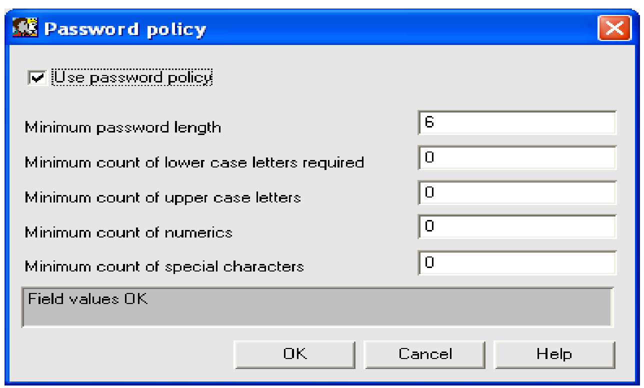
Putting it all together
Network architecture



Putting it all together
System hardware

Cyber security

- Password protection
- Auto logout after inactivity
- Password policies
- Security events logging
- Security Scripts
- Deployment Guideline



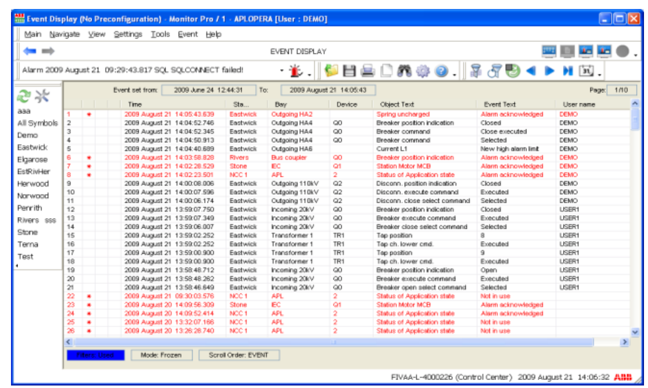


ABB value chain

Partnership

Collaboration

Coordination

Execution

Results

System Design → Project Management → Engineering & Procurement → Installation → Testing & Commissioning → Training → Services

We support you in every step of your project

Distribution automation in action
ABB Smart Grid Center of Excellence (COE)

- Single point of contact to leverage ABB's proven expertise as a worldwide Transmission & Distribution (T&D) Operations Technology (OT) and Information Technology (IT) system provider.
- Displays many of the products and solutions from ABB's smart grid portfolio and allows utilities to get engaged with live functional demonstrations.
- Integrated Verification Center where utilities can collaborate with ABB engineers to verify the integration and interoperability of smart grid solutions between vendors and manufacturers.

Final takeaways

- VVO systems have been proven to provide positive NPV investments
- Increased focus on energy efficiency and retirement of generation pressuring utilities to find alternate ways to maximize value of new and existing capital investments
- Centralized automation systems provide system synergies, including:
  - Distribution (“outside the fence”) SCADA
  - Distribution Management Systems (DMS)
  - Outage Management Systems (OMS)
  - Automatic Reconfiguration (FDIR, FLISR, etc.)
  - Remote access to distribution devices through wireless infrastructure
- Rethink the strategy – move from schedule based to condition based maintenance
- VVO systems enable you to keep your field devices on-line and functioning properly!

Thank you for your participation

Shortly, you will receive a link to an archive of this presentation.

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