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American Electric Power's Experience with Applying Technology on the Distribution System

Presentation to:

Electric Power Industry Conference (EPIC)

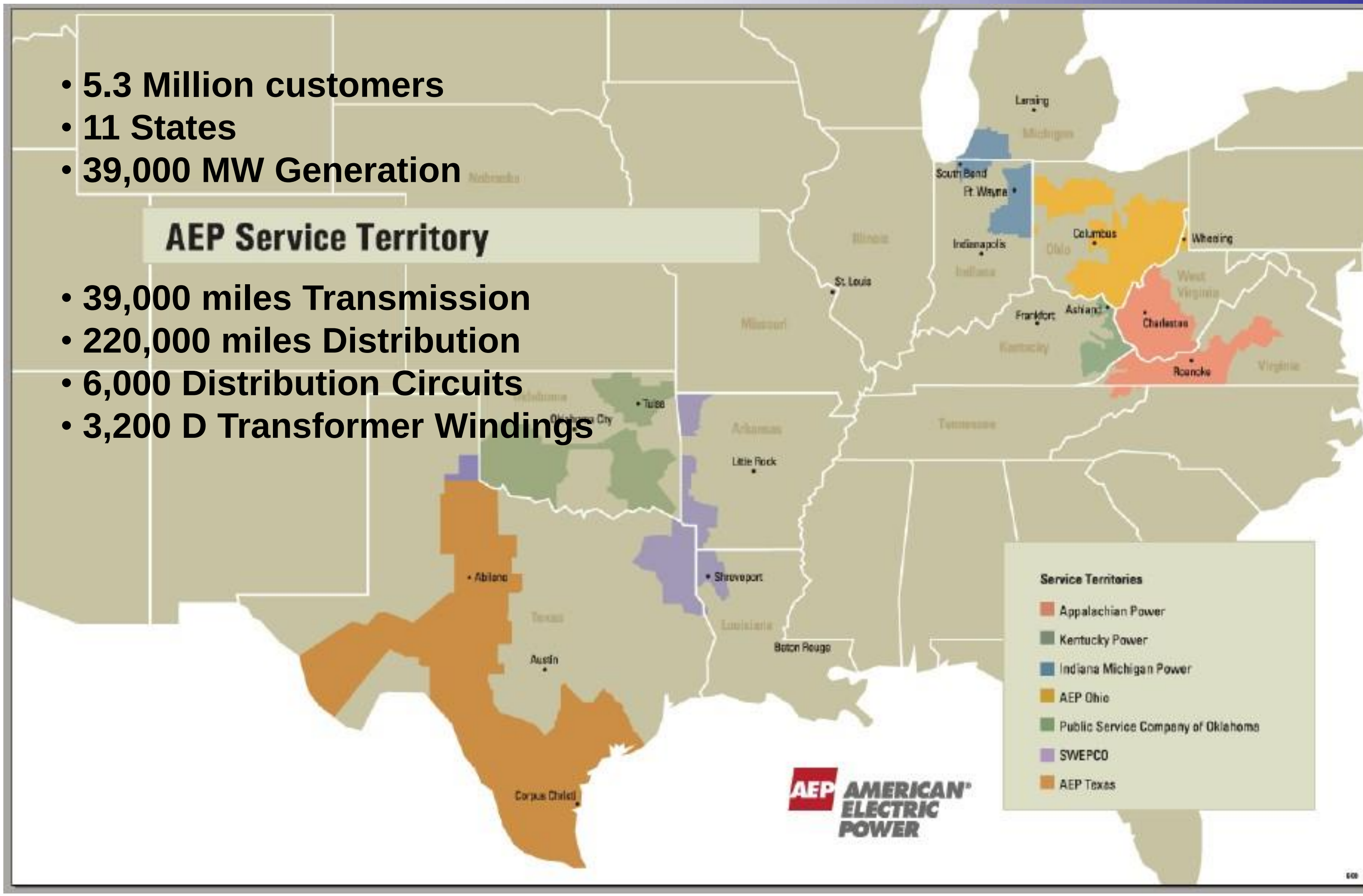
November 12, 2013
Tom Weaver, PE

AEP System Overview

- 5.3 Million customers
- 11 States
- 39,000 MW Generation

AEP Service Territory

- 39,000 miles Transmission
- 220,000 miles Distribution
- 6,000 Distribution Circuits
- 3,200 D Transformer Windings



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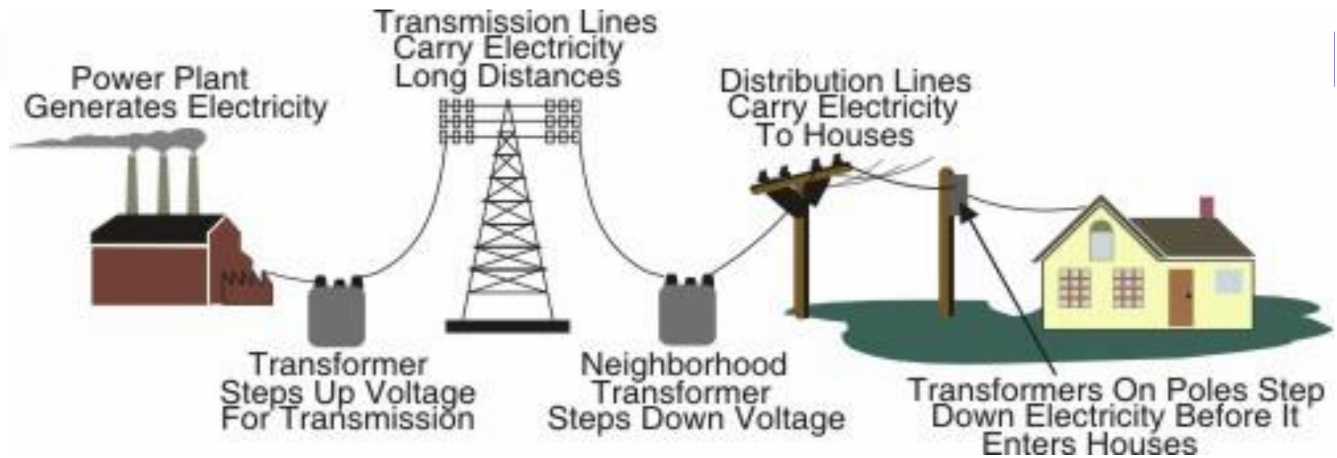
The Evolution of the Electric Utility System

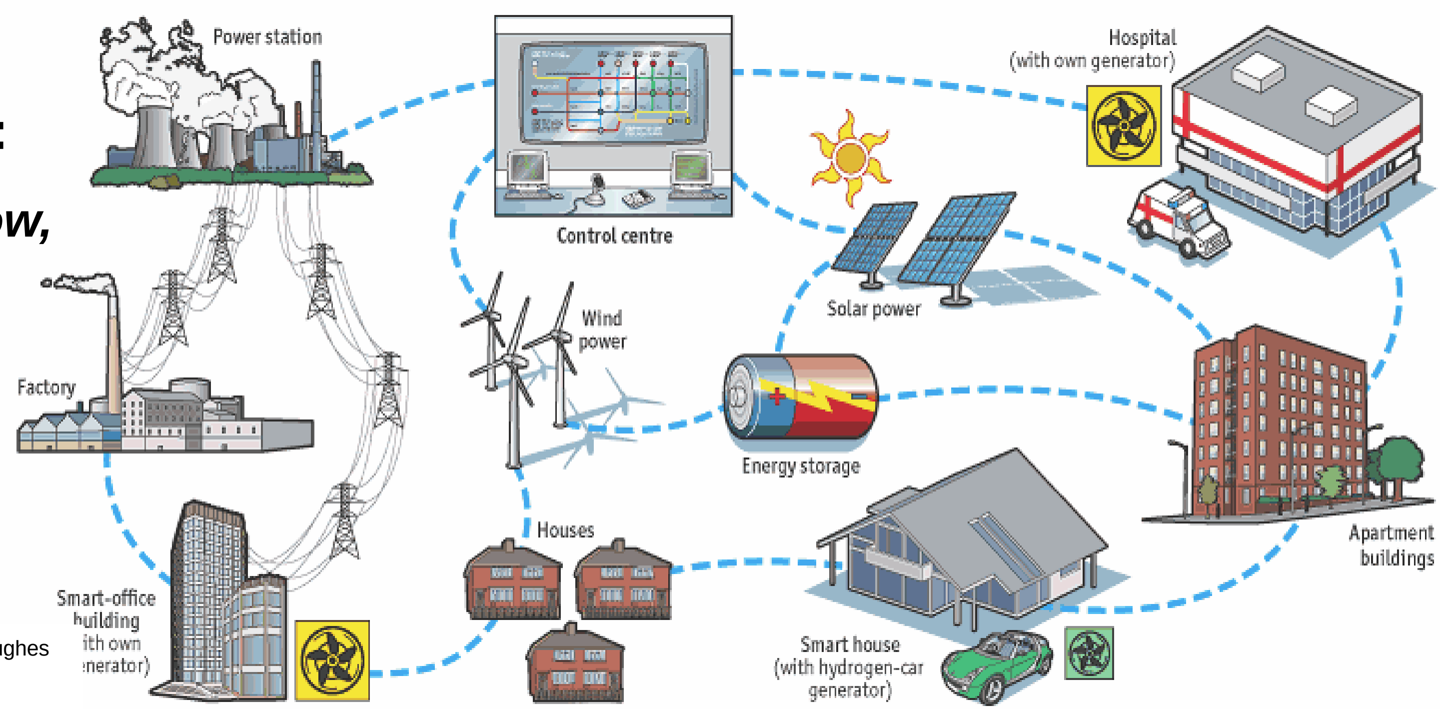
Before Smart Grid:

One-way power flow, simple interactions



After Smart Grid:

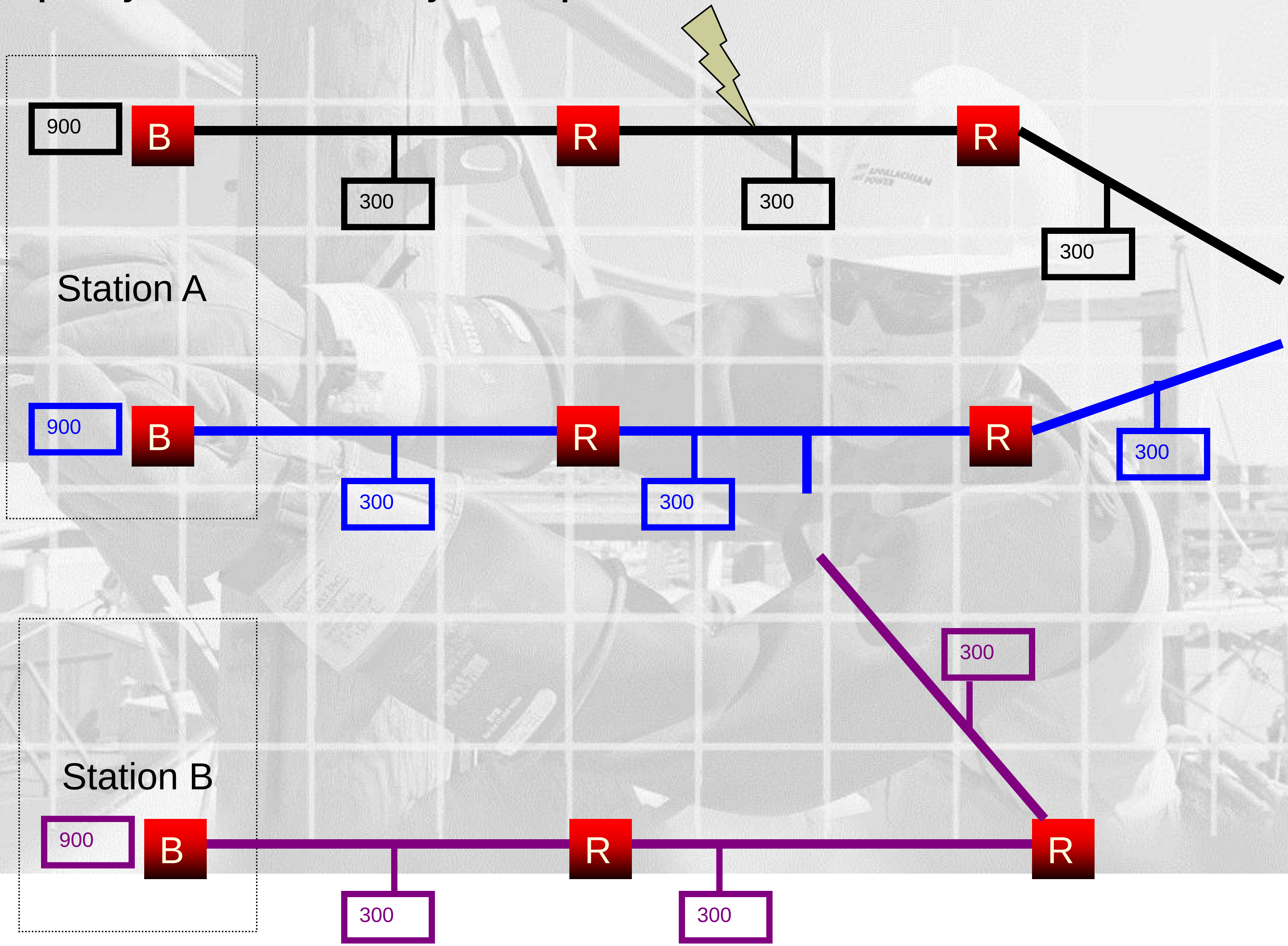
Two-way power flow, multi-stakeholder interactions



Sources: *The Economist*; ABB

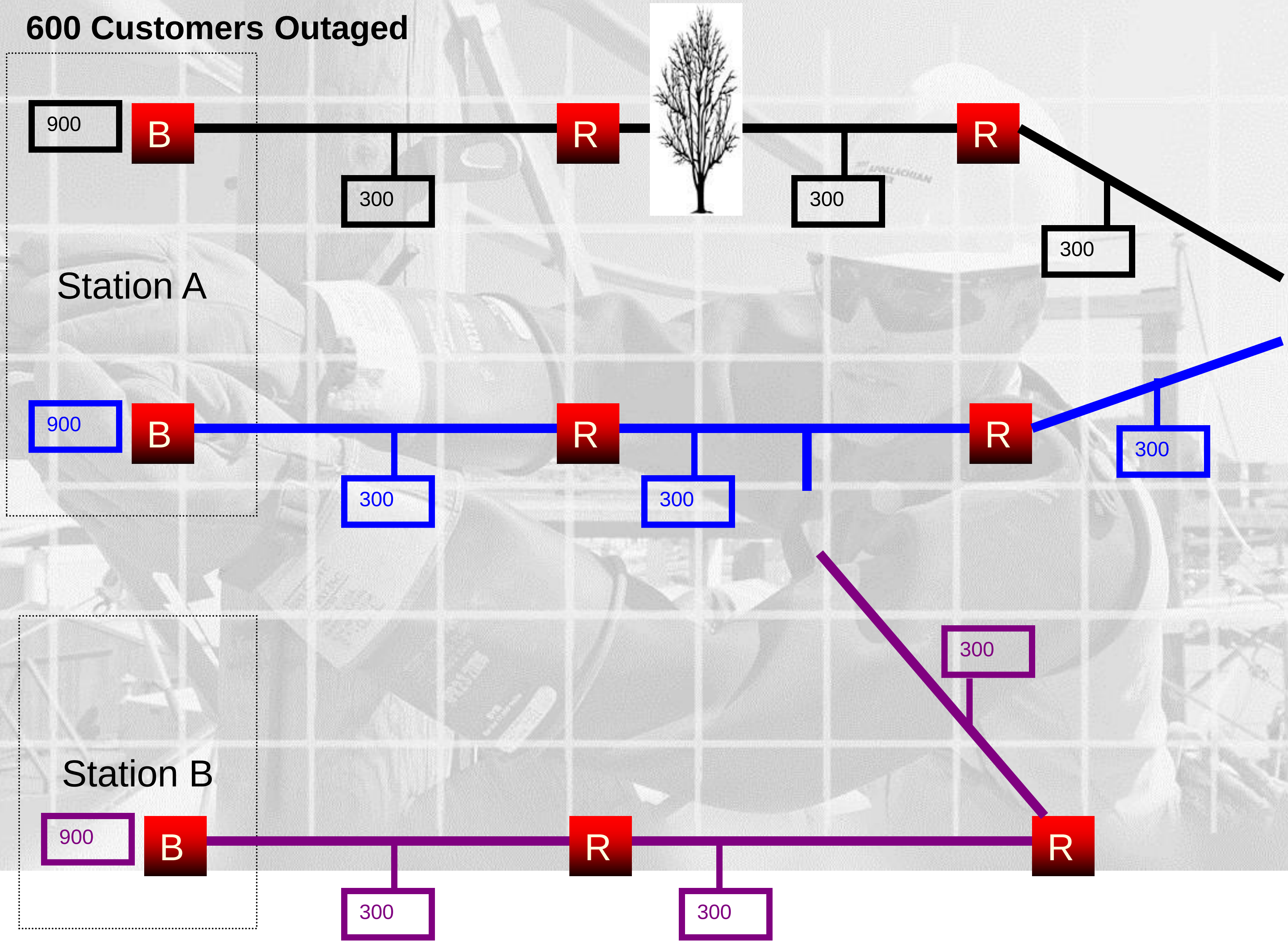
Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008

Temporary Fault – Momentary Interruption



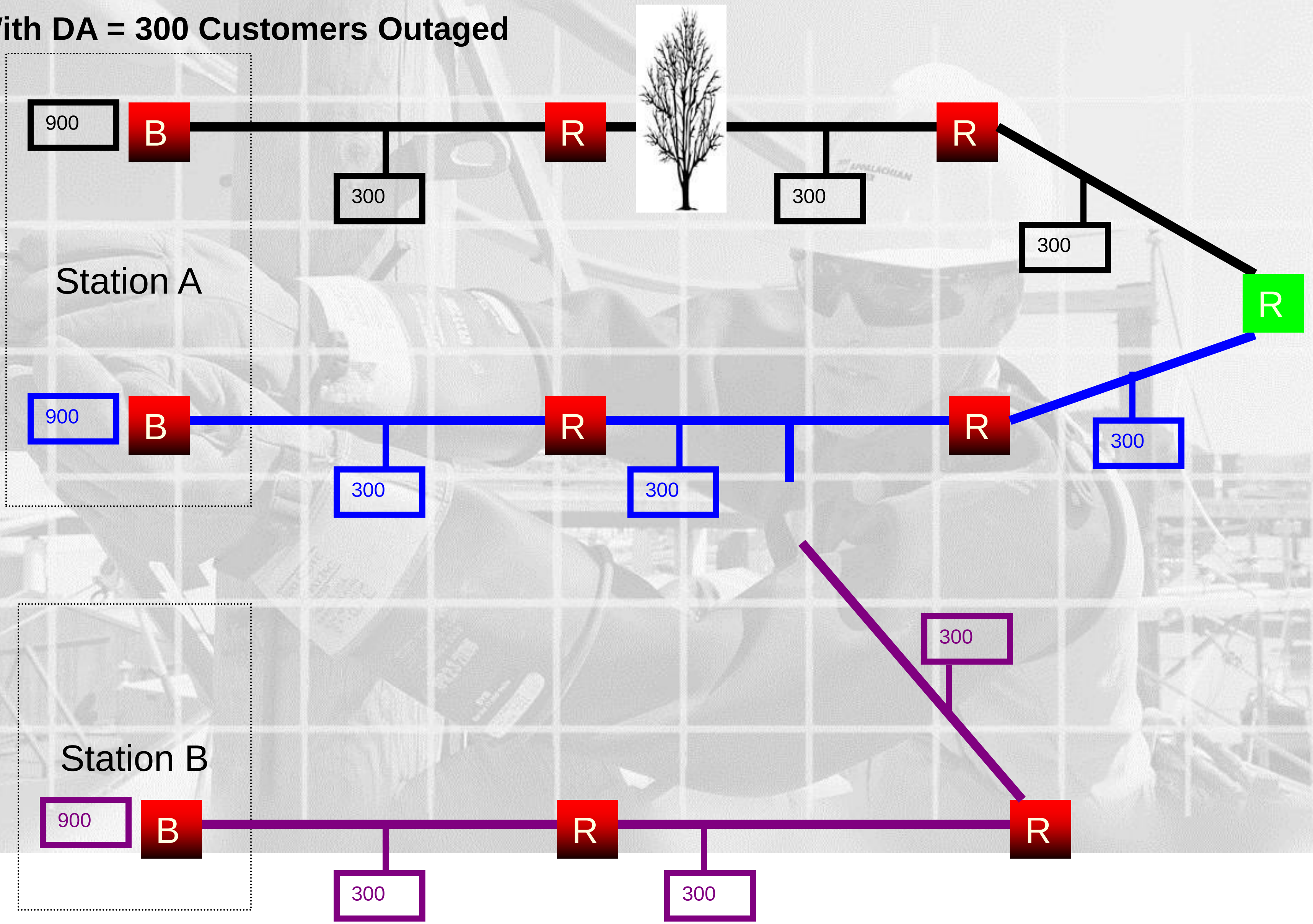
Permanent Fault

600 Customers Outaged



Permanent Fault

With DA = 300 Customers Outaged



Energy Storage

Substation Scale Battery

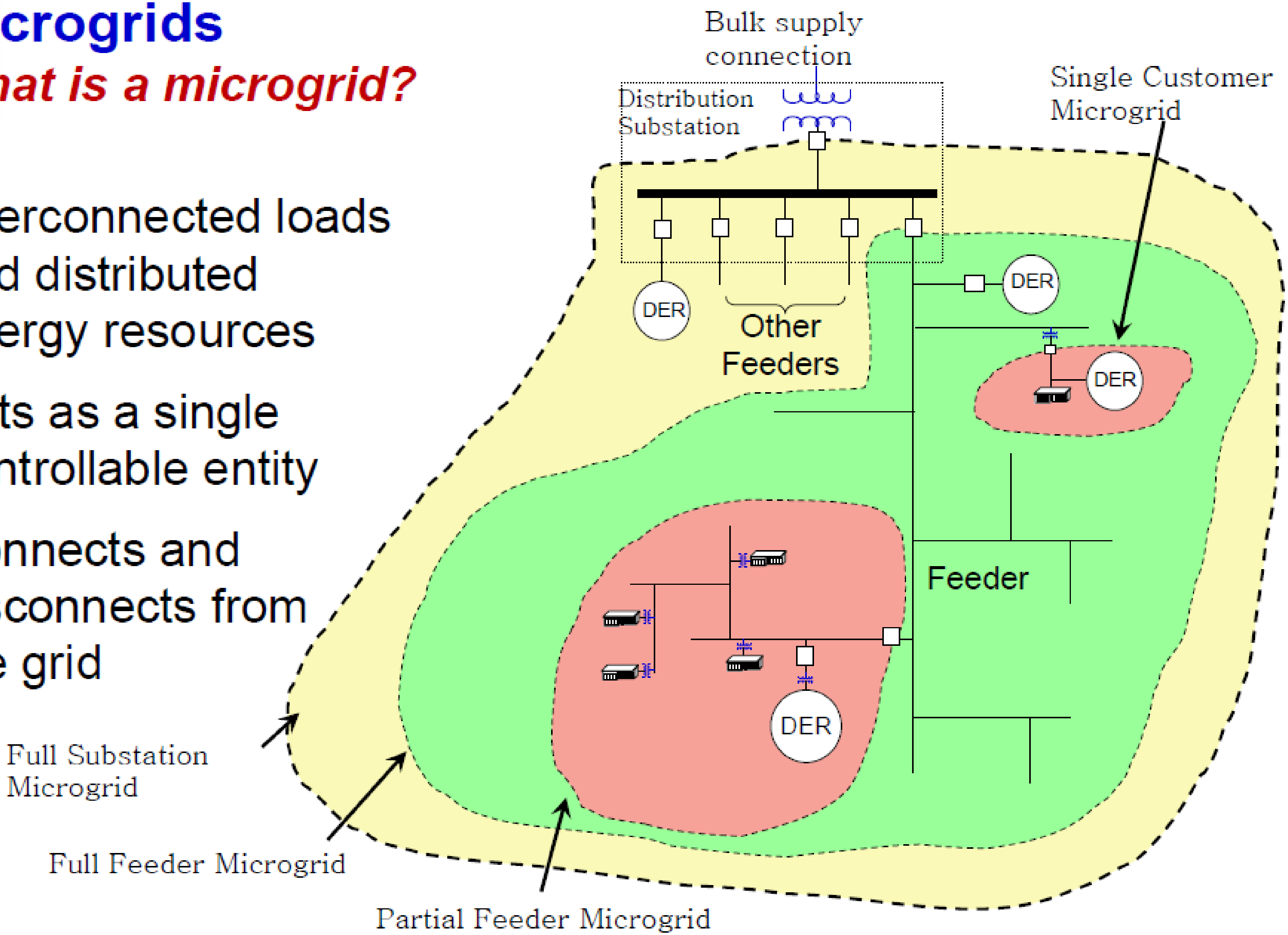
- **2006:** 1 MW, 7.2 MWh; Deferred substation upgrade in Charleston, WV
- **2008:** Three installations; 2 MW, 14.4 MWh each; With “islanding” in Bluffton,OH; Balls Gap,WV; East Busco,IN
- **2010:** 4MW, 25MWh; Installed in Presidio, TX

Community Energy Storage

- Small distributed energy storage units connected to the secondary of transformers serving a few houses or commercial loads.
- 25 KVA units are being tested and evaluated.

Microgrids
What is a microgrid?

- Interconnected loads and distributed energy resources
- Acts as a single controllable entity
- Connects and disconnects from the grid



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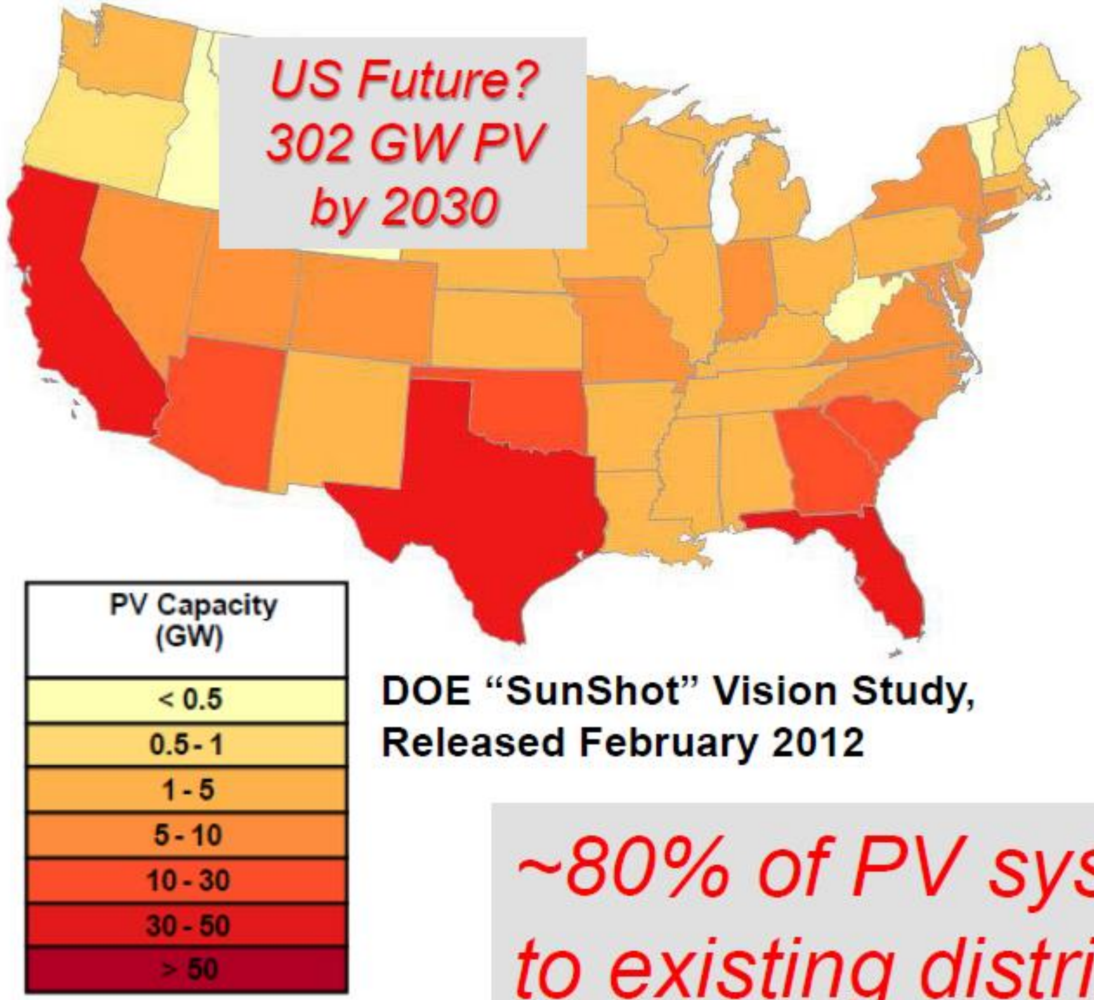
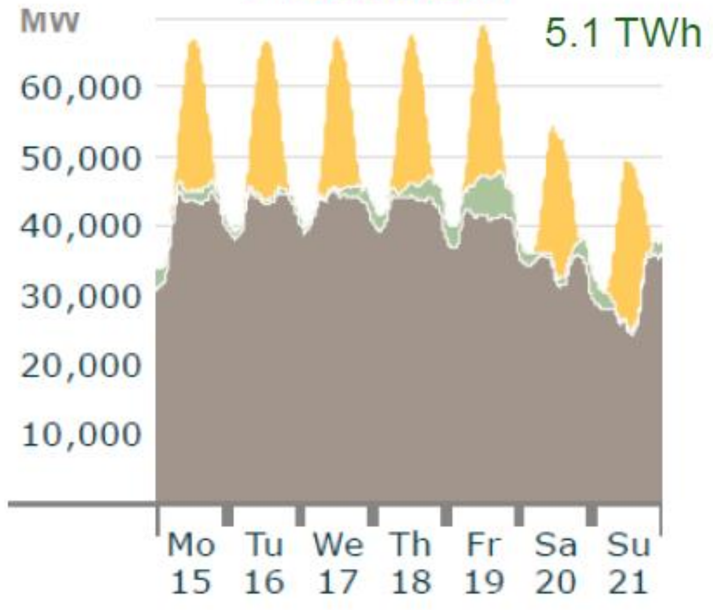
Inverter-Connected Solar is Coming
Is the grid ready for PV?



DOE "SunShot" Vision Study, Released February 2012



~80% of PV systems connected to existing distribution

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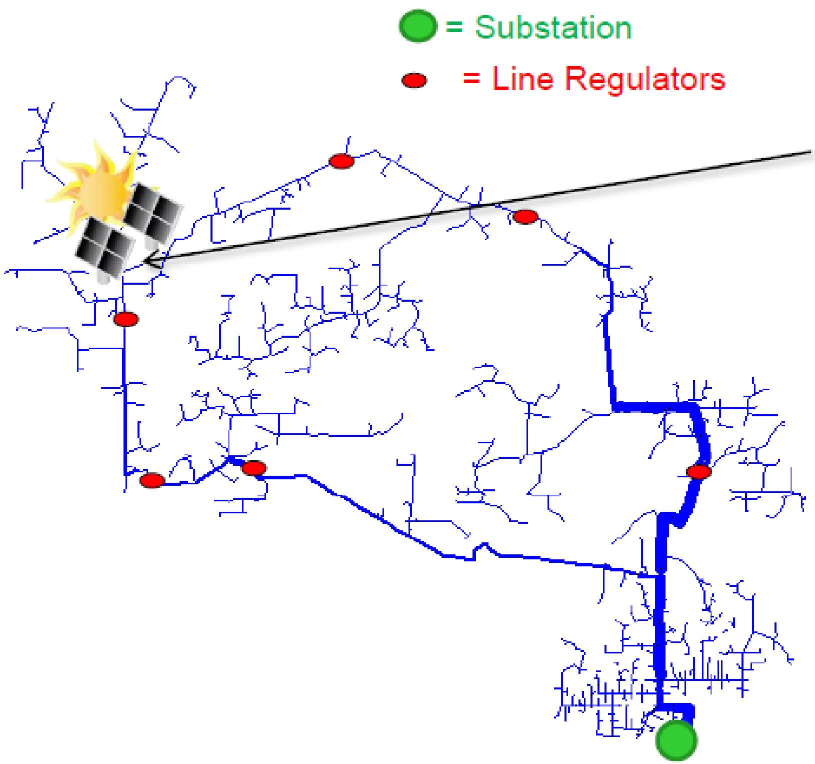
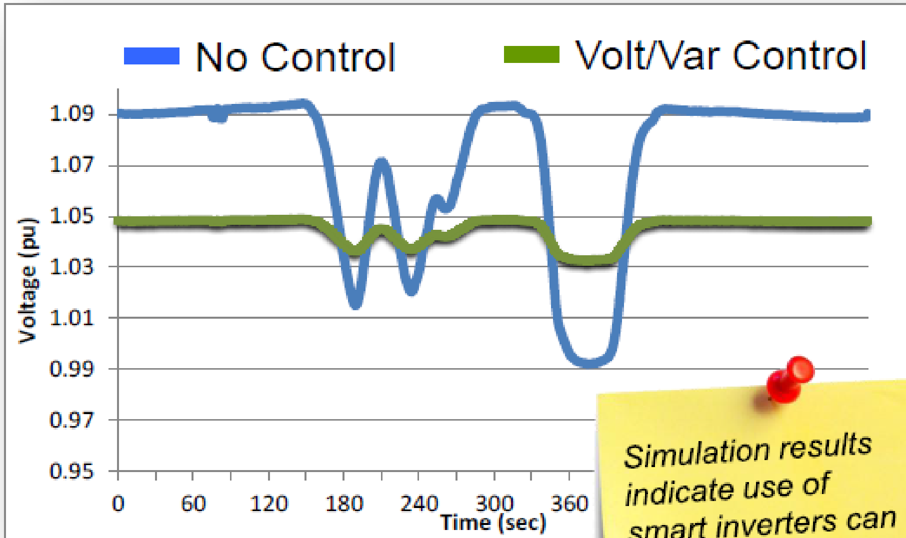
Case Study: Solar PV Impact on Feeder Voltage

Smart Inverters Mitigating Voltage Issues



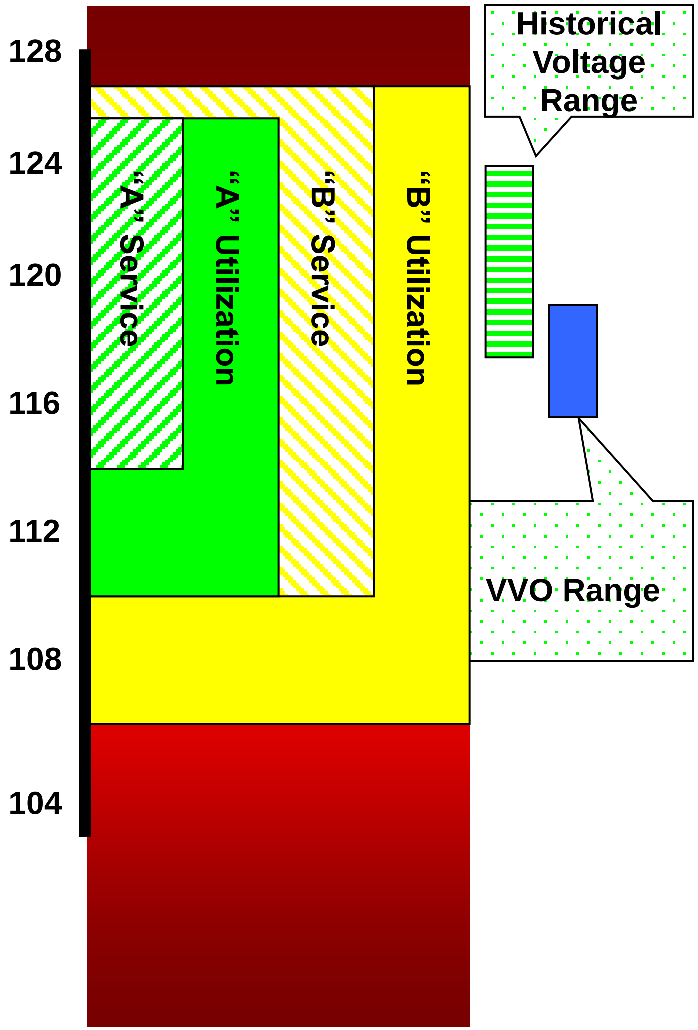
Simulated Voltage at END of feeder



Simulation results indicate use of smart inverters can mitigate many of the voltage issues resulting from PV

Volt VAR Optimization (VVO) Overview

- **Technology and infrastructure upgrades integrated into the electric distribution system to optimize voltage levels**
  - Utilizes communications and computerized intelligence to control voltage regulators and capacitors on the distribution grid
  - Optimizes voltage and power factor based upon selected parameters
  - Algorithm uses end of line monitoring feedback to ensure minimum required voltage maintained



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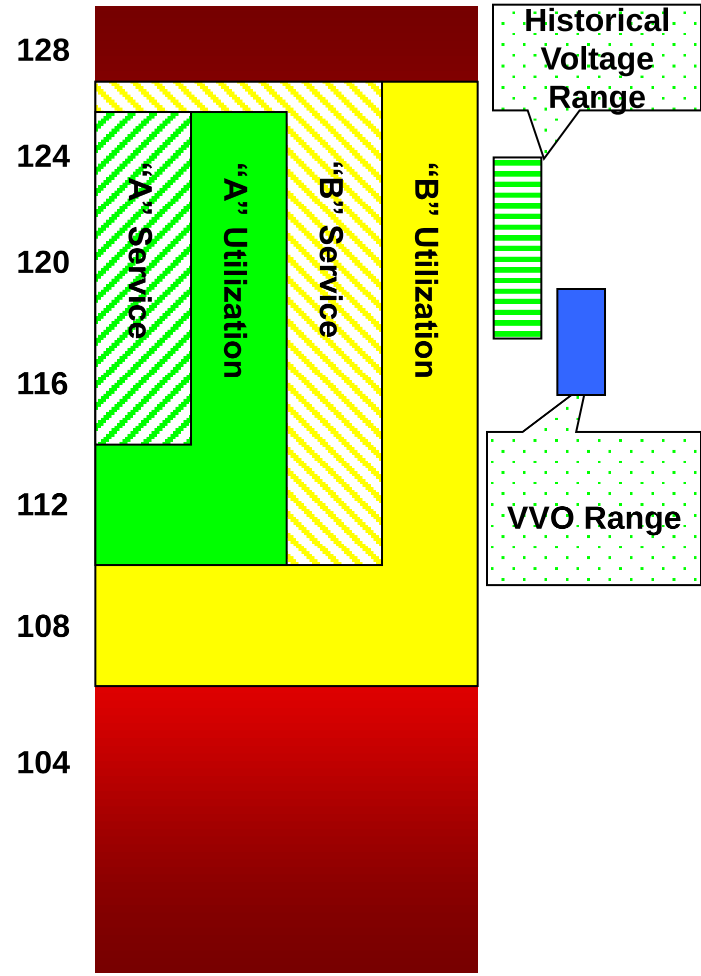
Volt VAR Optimization – Basic Concepts

CVR Calculation – 60 W Incandescent Bulb

	Watts	Voltage	Amps	Ohms
Rated Values	60.000	120.000	0.500	240.000
Values @ 125 V	65.104	125.000	0.521	240.000
Values @ 121.25 V (3% less than 125V)	61.257	121.250	0.505	240.000
Energy Reduction from 3% Voltage Reduction	3.848			
% Energy Reduction	5.91%			
Conservation Voltage Reduction Factor (CVR) = % Energy Reduction /% Voltage Reduction	1.97%			



Volt VAR Impacts on Customer's Motors

EPRI EL-2036
Volume 1
Project 1419-1
Final Report
September 1981

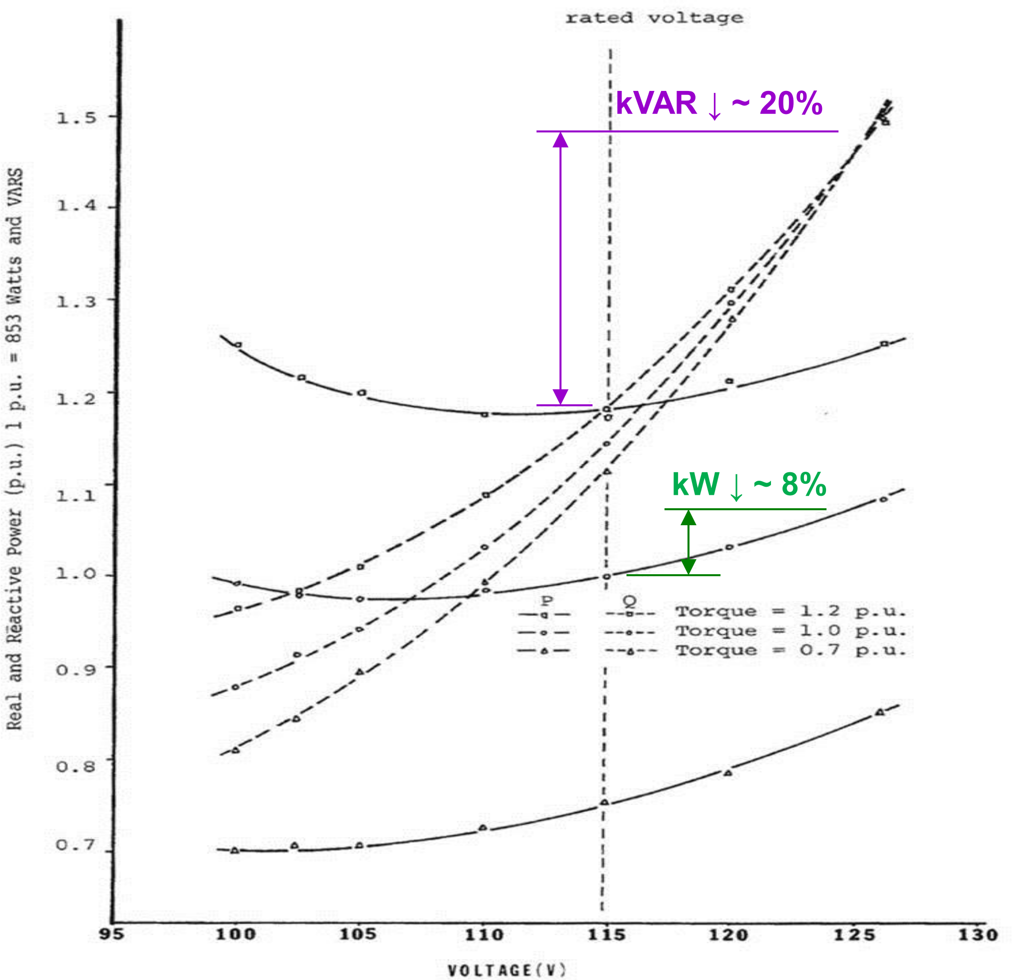
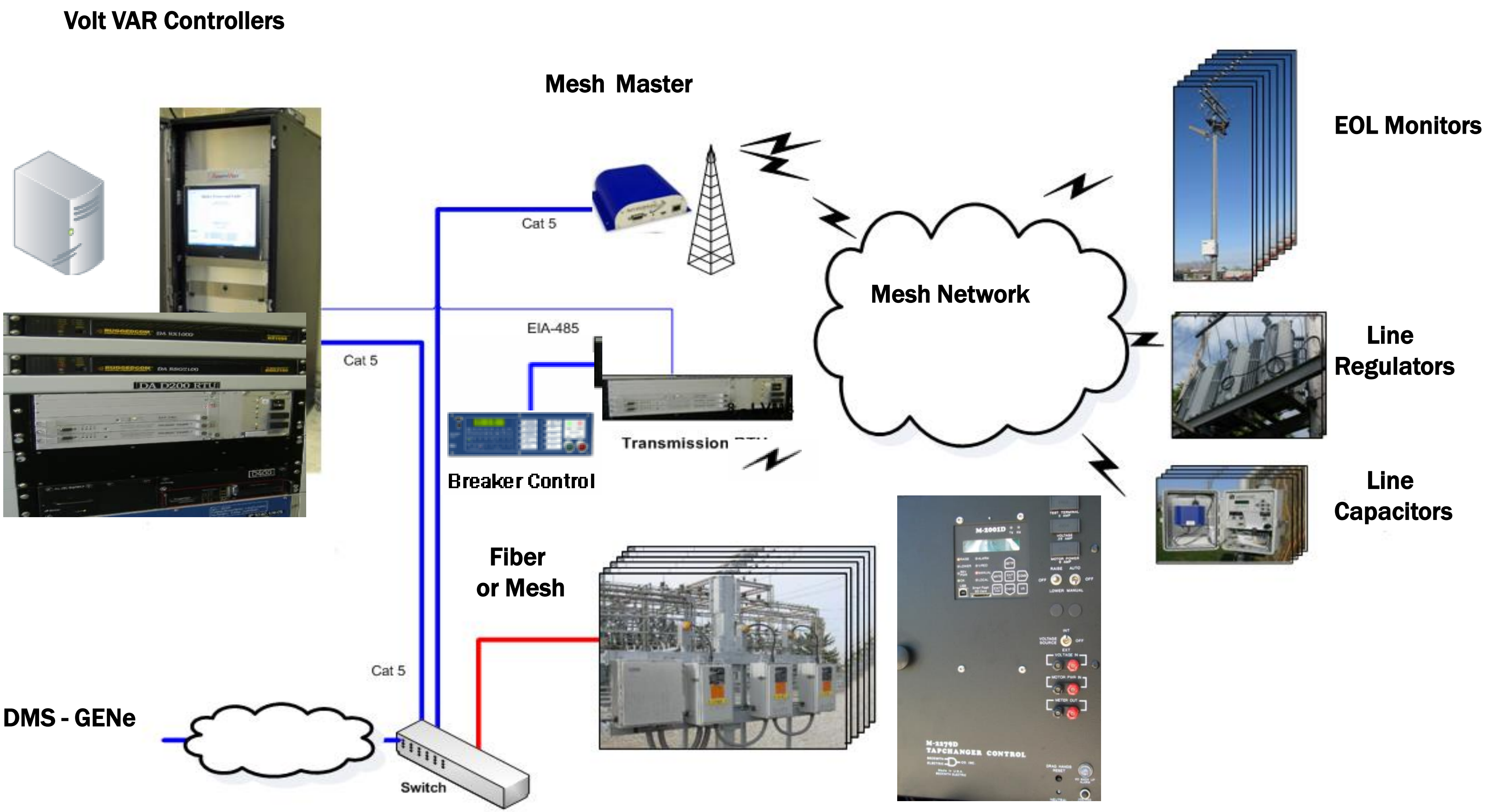


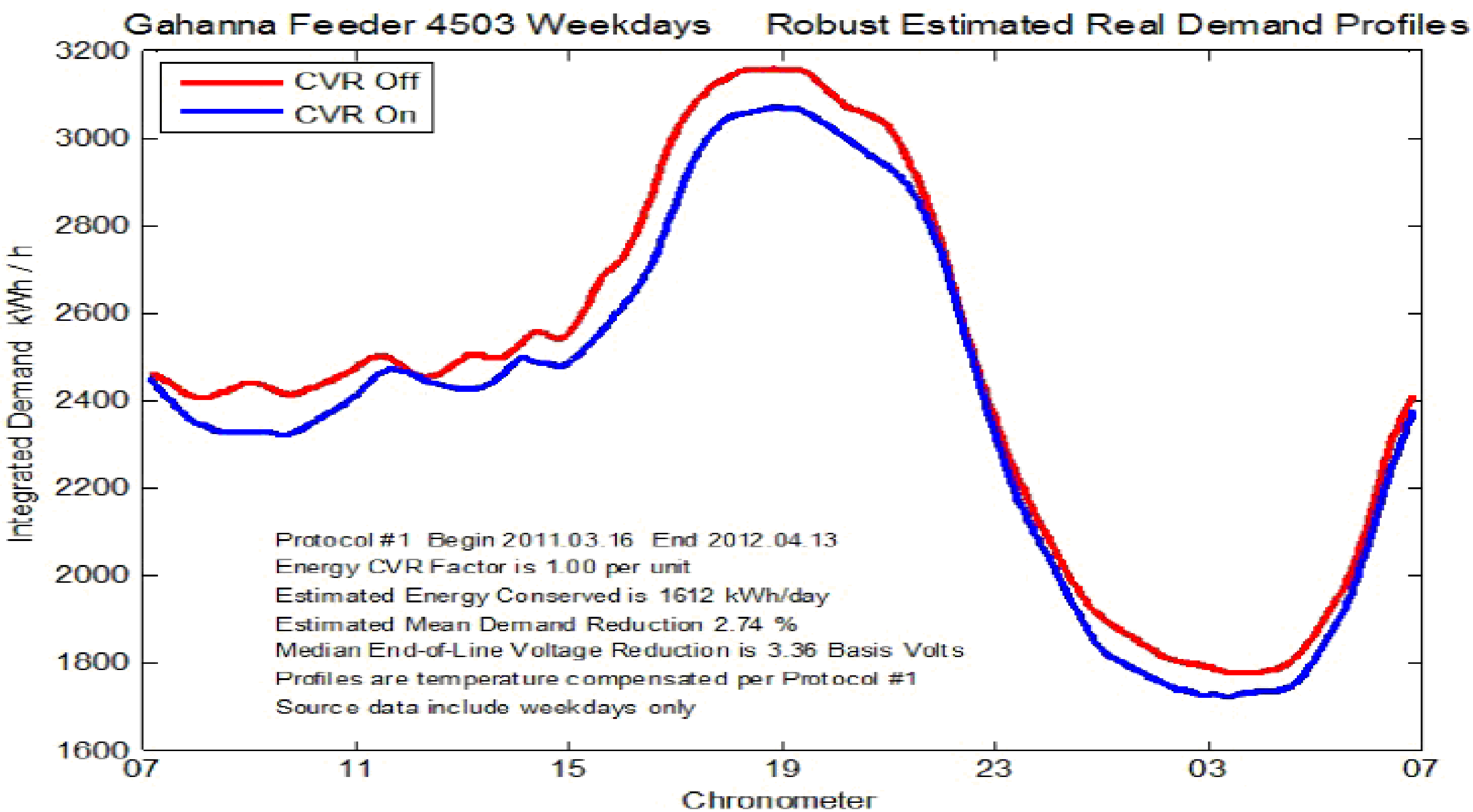
Figure 3-156 Input real and reactive power as a function of applied voltage for motor No.1, mfr. A, with constant torque loads.

Real Power consumption is 8% lower @ 115V than at 125V

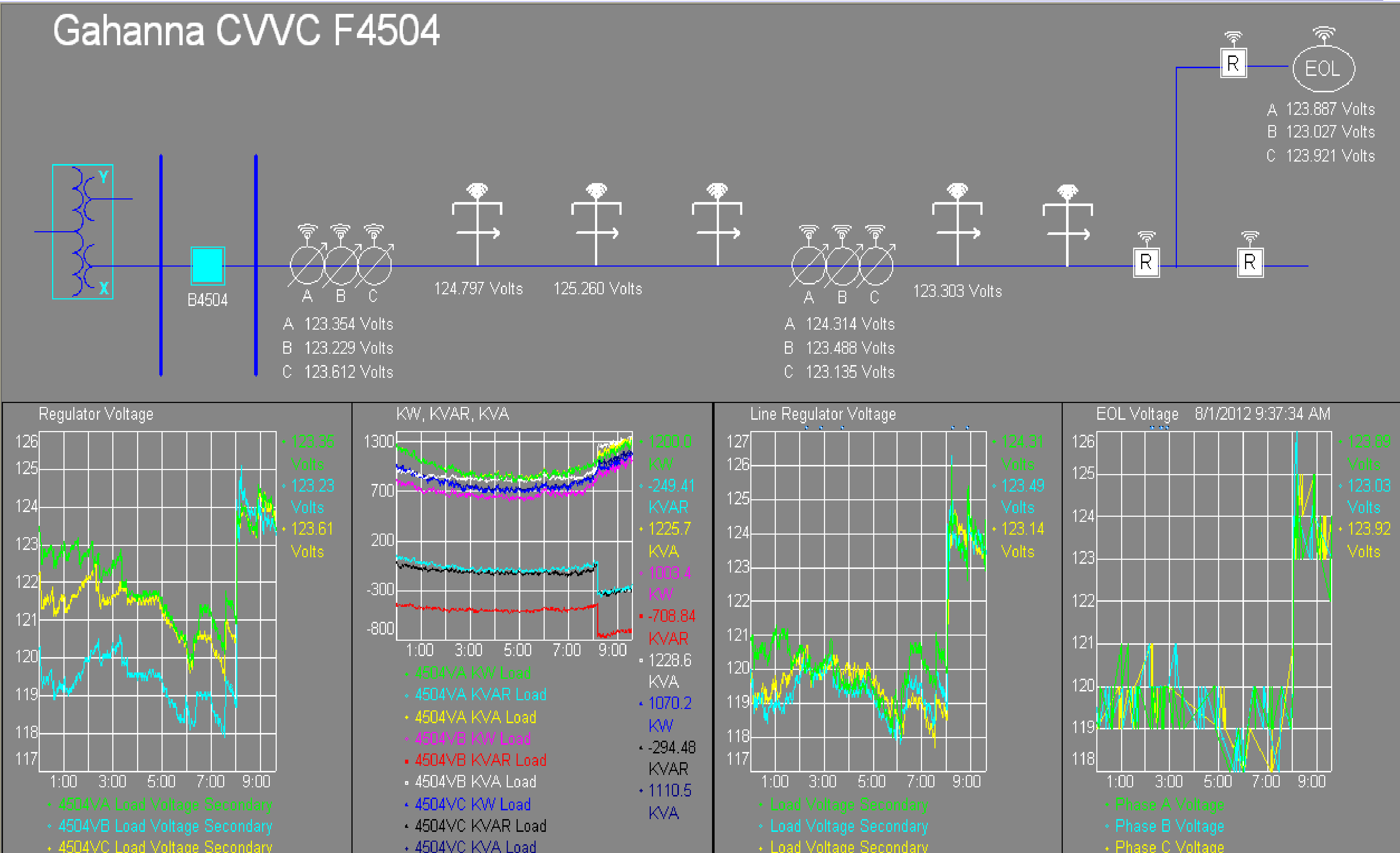
Volt VAR Optimization Architecture



Example of Energy Savings on Circuit 4503 using Utilidata AdaptiVolt System



SCADA / PI View



Example: Customer Demand and Energy Savings

1100 kW
609,000 kWh

1067 kW
590,730 kWh

Volt Var Optimization will reduce customer peak demand and energy consumption <u>at the meter</u>

VVO for Energy Efficiency / Capacity Reduction

- **Energy Efficiency (24/7 Operation)**
  - Help meet state Energy Efficiency targets
  - Receive incentives / participate in DR markets
  - TRCs 2 to 3 – better than many current programs
  - Reduce Energy Consumption by Customers
  - Not limited by "participation rates"
  - Reduce Emissions
  - Relieve Transmission Congestion

- **Capacity (Demand Reduction Only)**
  - Reduce amount of capacity required at peak / critical times
  - Short payback period if generation charges are based on peak demand
  - Defer investment in capacity replacement or upgrades
  - Engage in DR Market
  - Relieve Transmission Congestion

SMART Circuits will include:

1. **Two way communication amongst devices with central control center visibility and automated outage recovery**
   a. Industry experience has yielded a 30% reliability improvement
   b. Permits remote equipment switching without truck roll

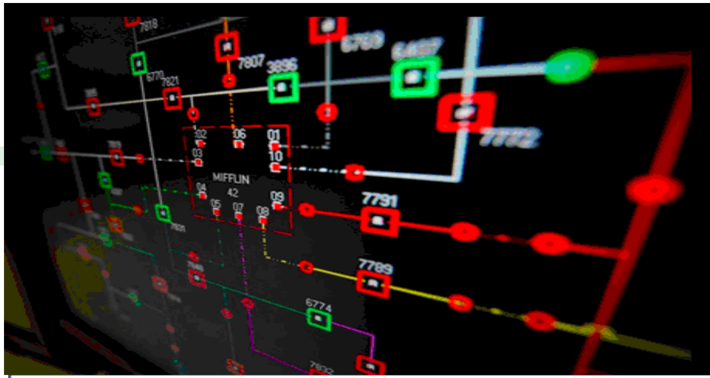
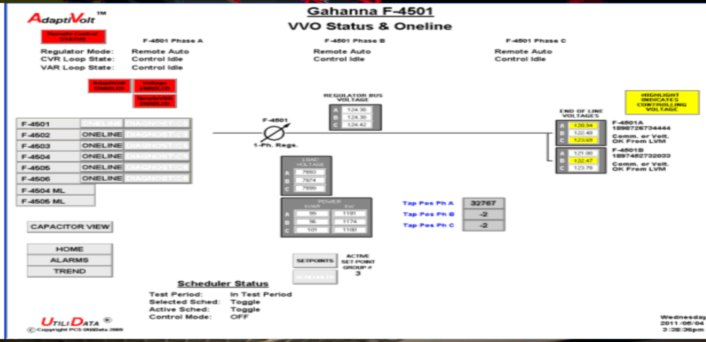
2. **Equipment sensors that provide real time condition/status**
   a. Avoid equipment overloads
   b. Proactively identify potential failures
   c. Enhances power quality monitoring
   d. Supports diagnostic & monitoring of equipment to support asset renewal programs

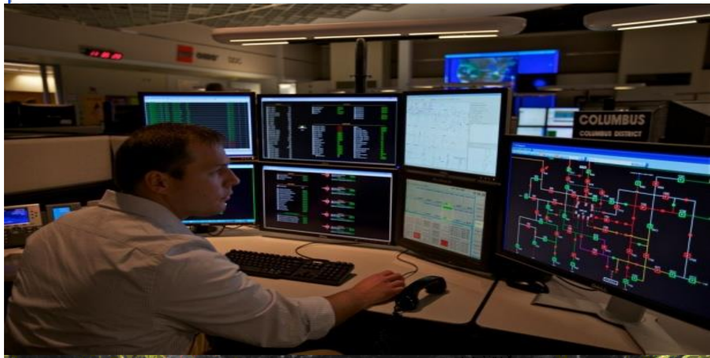
3. **Integrated back office systems to provide remote and automated data collection, analysis, visualization and action**

4. **Asset Management analytical tools:**
   a. Preventive Equipment “Asset Health Index”
   b. Supports asset investment planning to optimize power transformer and other equipment replacements
   c. Enables condition-based maintenance programs

5. **Preventive Automated Fault Anticipation & Location**

6. **Two way power flow support – easy integration of distributed renewable generation**



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gridSMART®

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Questions?