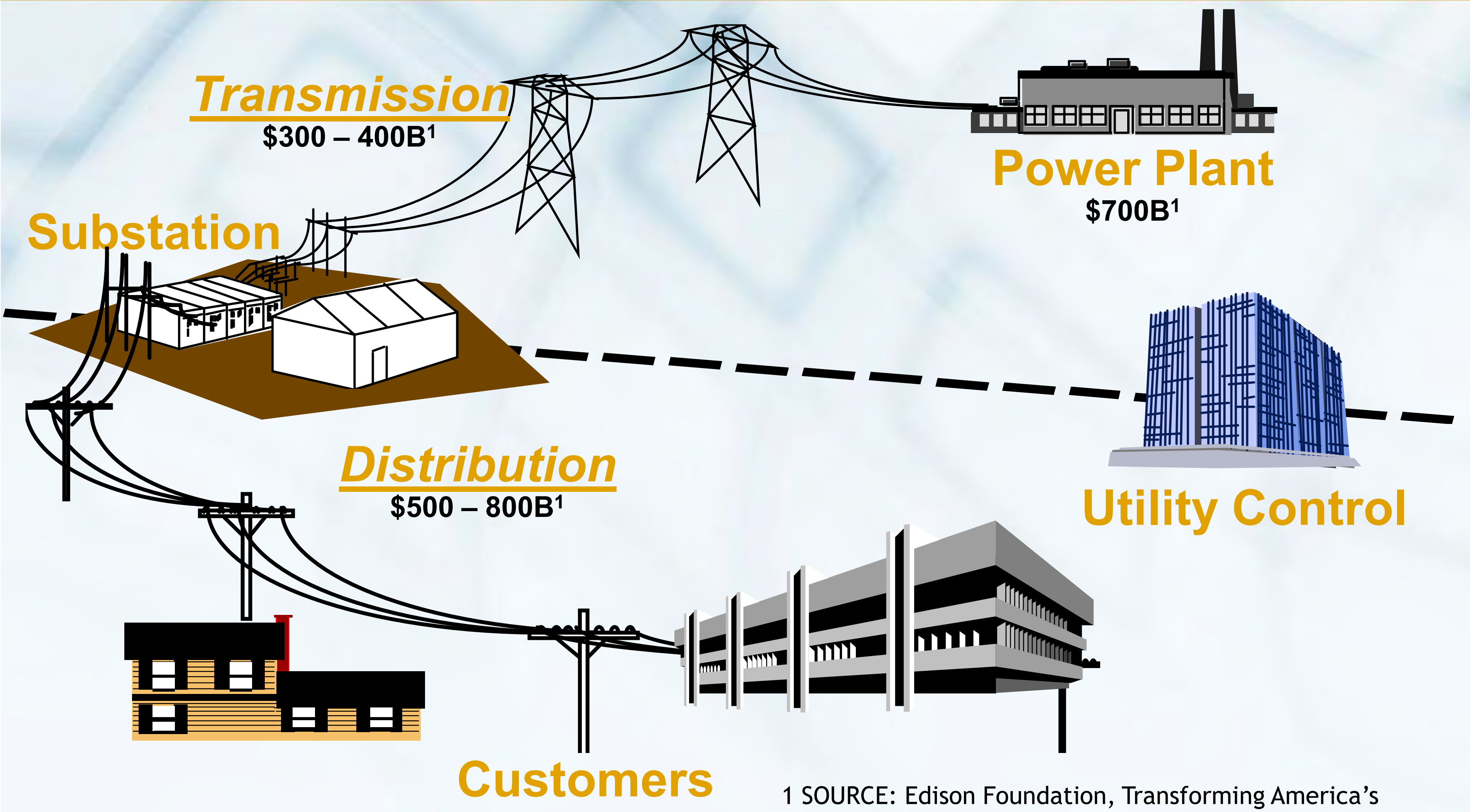
IEEE Nashville Chapter

Technology Roadmap for Grid Automation

November 2010

R·W·BECK
An SAIC Company

Projected Expenditures 2010 - 2030



1 SOURCE: Edison Foundation, Transforming America's Power Industry: The Investment Challenge 2010-2030

Smart Grid

- Overlay of a communication and information system on top of the existing power system for purposes of visibility and control

Smart Grid

DOE's Characteristics of the "Smart Grid"

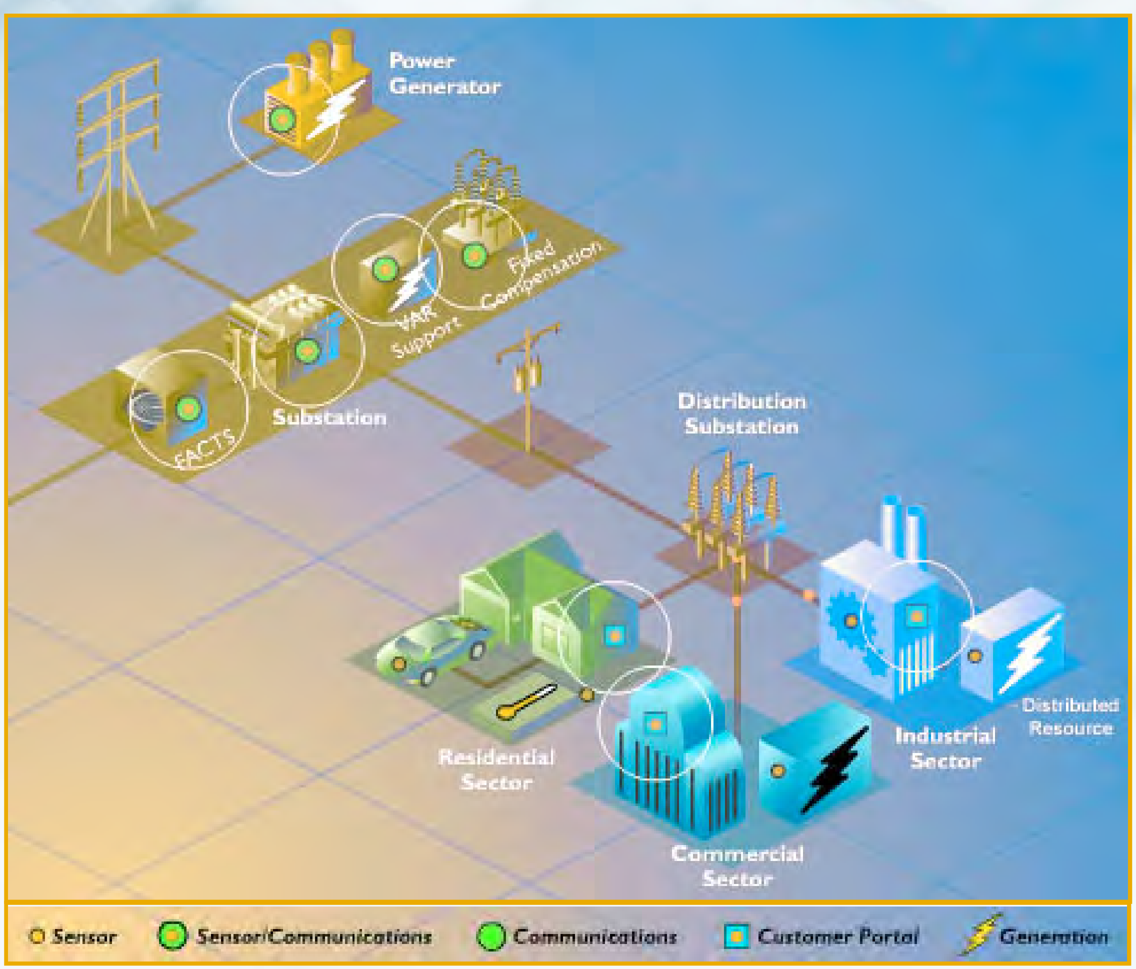
1. Be able to heal itself
2. Motivate consumers to actively manage their energy consumption
3. Resist attack
4. Provide higher reliability and quality of power
5. Accommodate all generation and storage options
6. Enable electricity markets to flourish
7. Run more efficiently

The Federal Story on the Smart Grid

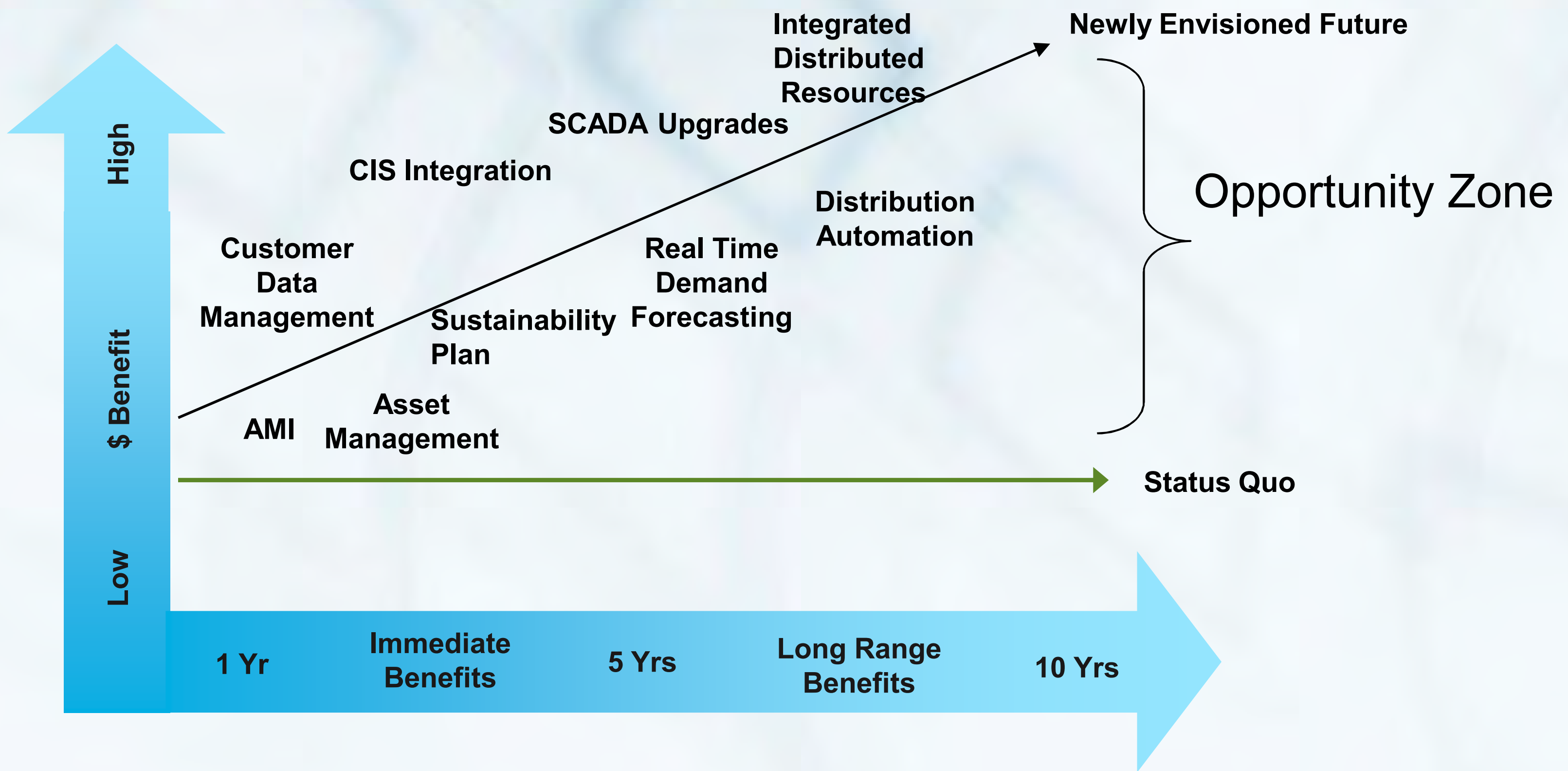
- $4 Billion in Stimulus Funding
  - $3.4 Billion in Investment Grants
  - $0.6 Billion in Demonstration Projects

Smart Grid – Components

- AMI and Customer Technologies
- Electric Vehicles
- Demand Response (DR)
- Distributed Resources (DG & Electric Storage)
- Data Management (EMS, DMS, OMS)
- Substation Automation (SA)
- Distribution Automation (DA)



Developing a Technology Roadmap



Advanced Metering Infrastructure (AMI)

- Definition of AMI refers to systems that incorporate automated meter reading, two way communications, and data management

Electric Vehicles

- Plug In Electric Vehicles(PHEV) – 5kw load during charging
- Vehicle to Grid (V2G) – sell demand response services to grid

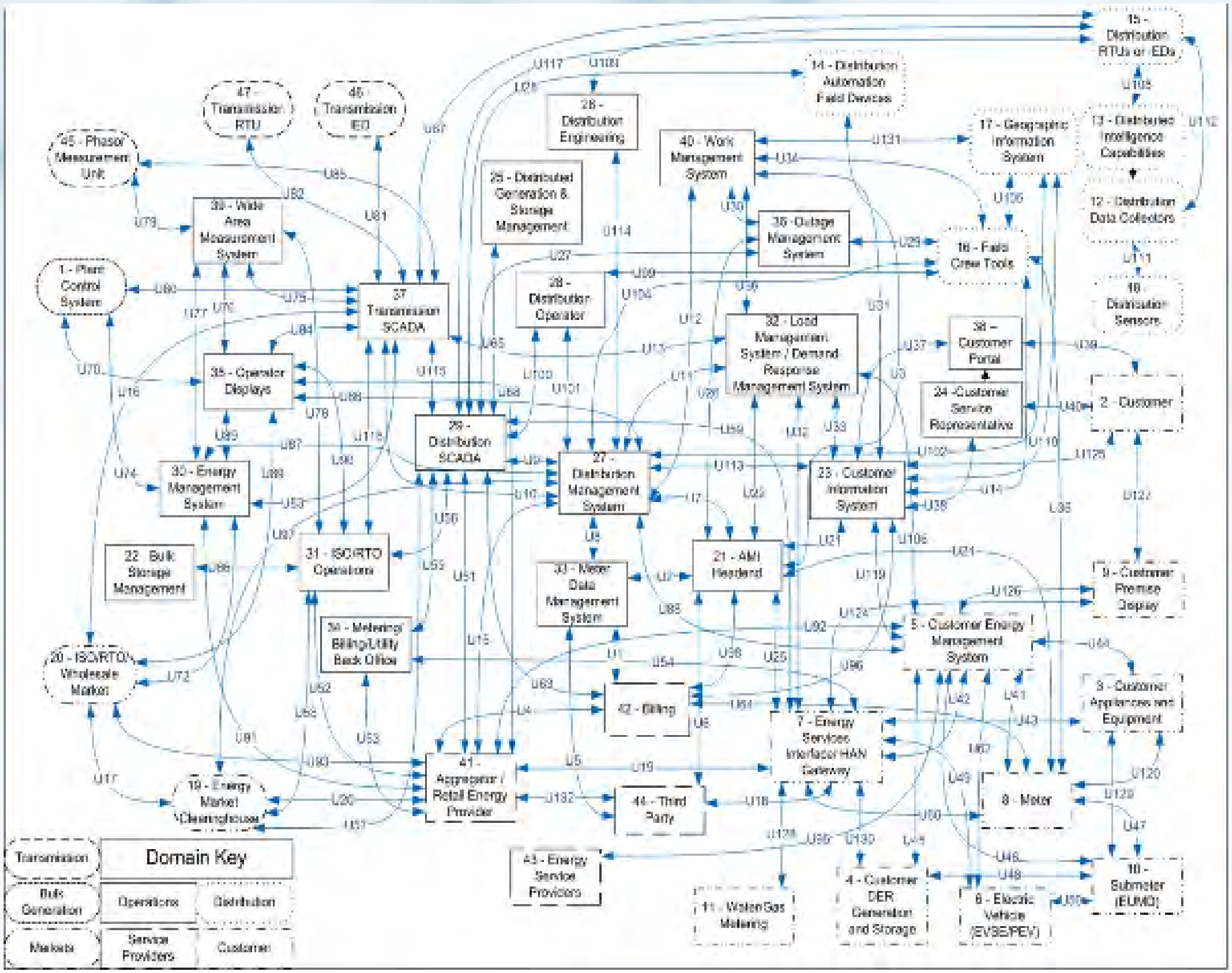
Demand Response

- Direct Load control of water heaters, air conditioning, etc.
- Passive load control – sending price signals to customers

Distributed Resources

- Solar
- Wind
- Biomass
- Diesel Generators
- Energy Storage (batteries, flywheels)

Data Management



- OMS
- DMS
- EMS
- SCADA
- CIS
- AMI
- Web portal

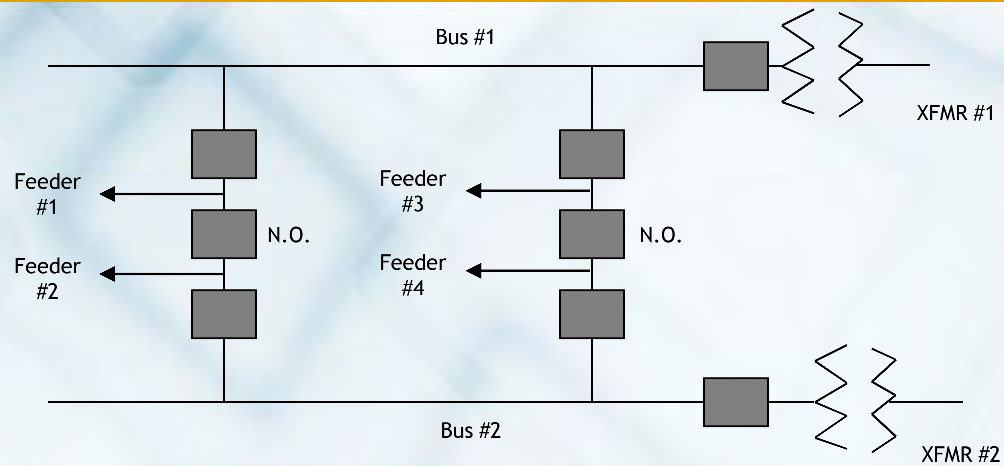
Substation Automation

- Communications to Substations & line devices
- Automated Breakers
- Microprocessor-based relays
- Voltage Optimization

Self-healing T&D systems – Substation Automation

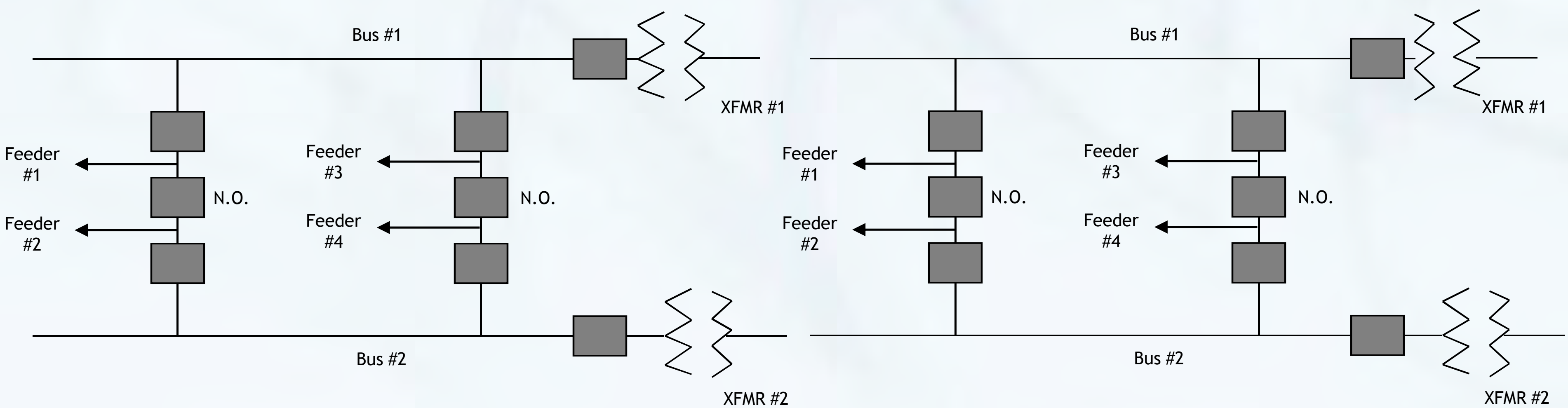
Traditional Scheme

(Breaker-and-a-half Bus Configuration)

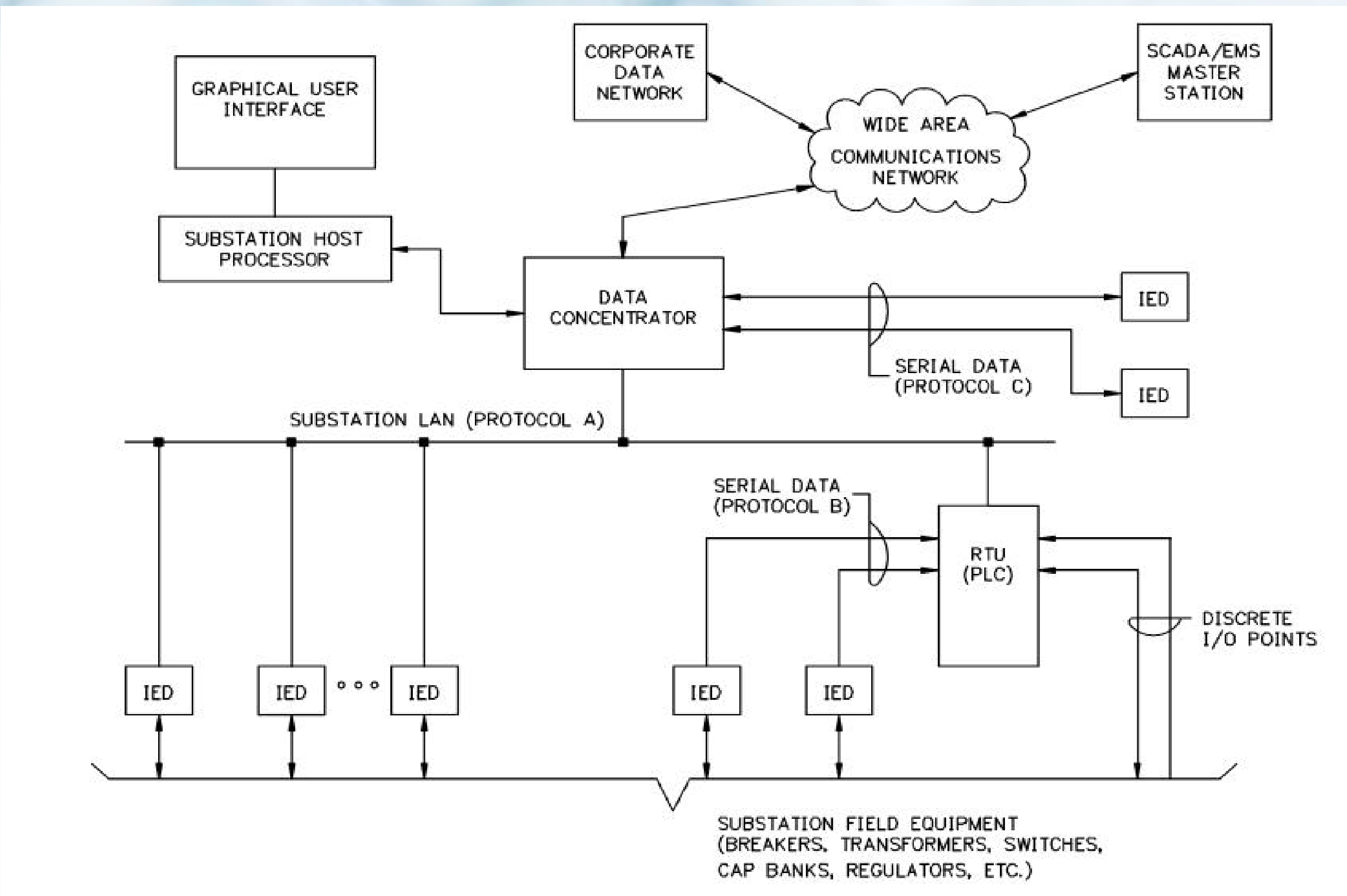


Advanced Scheme

(Multiple Substations)



SA Architecture



Architecture Components

- Intelligent Electronic Devices (IEDs)
- Data concentrators
- Remote Terminal Units (RTUs)
- SCADA
- Telecommunications

Communications

- Medium:
  - Power line carrier
  - Copper
  - Fiber
  - Wireless & Radio
- Peer to Peer (meters, line devices)
- Substations can serve as gateways

Automated Breakers

- Breakers can house IEDs
- Improve remote operation
- Improve data acquisition (status, load, fault current, voltage)

Microprocessor-based Relays

- Aka – Intelligent Electronic Devices (IEDs)
- Allows remote operation & data collection
- Virtually eliminates mechanical failure & need for analog transducers
- Reduces overall wiring
- Enables self healing technology
- Provides decentralized data processing

Technology Needs

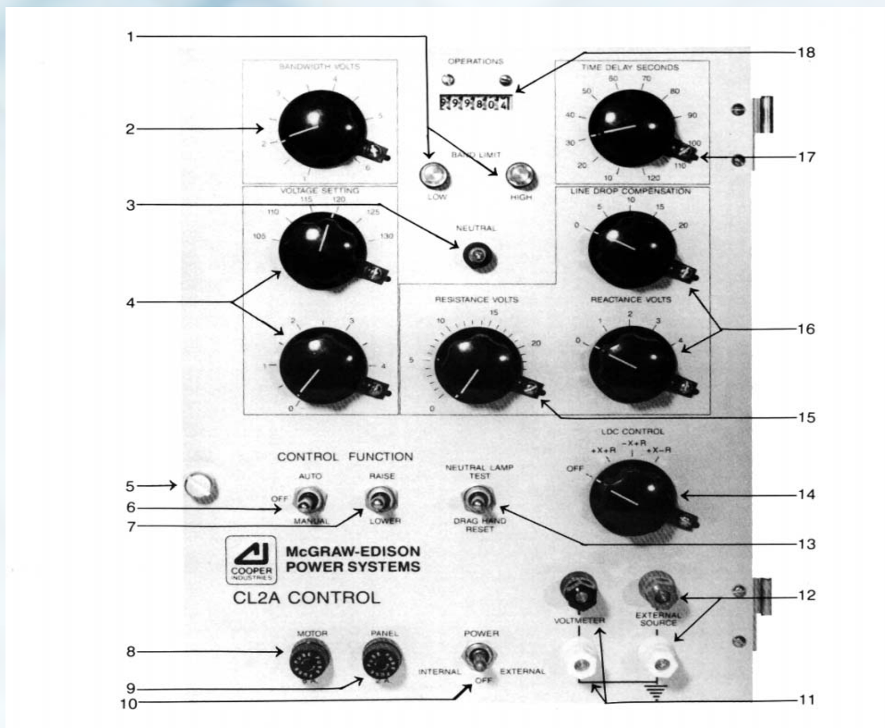
- Microprocessor based relays
- SCADA – including communications (peer to peer)
- Model of substation equipment (traditional scheme)
  - Relays settings
  - Circuit ratings
  - Control logic – can be decentralized
- Model of system (advanced scheme)- Centralized control logic

Voltage Optimization

Benefits on both sides of the meter

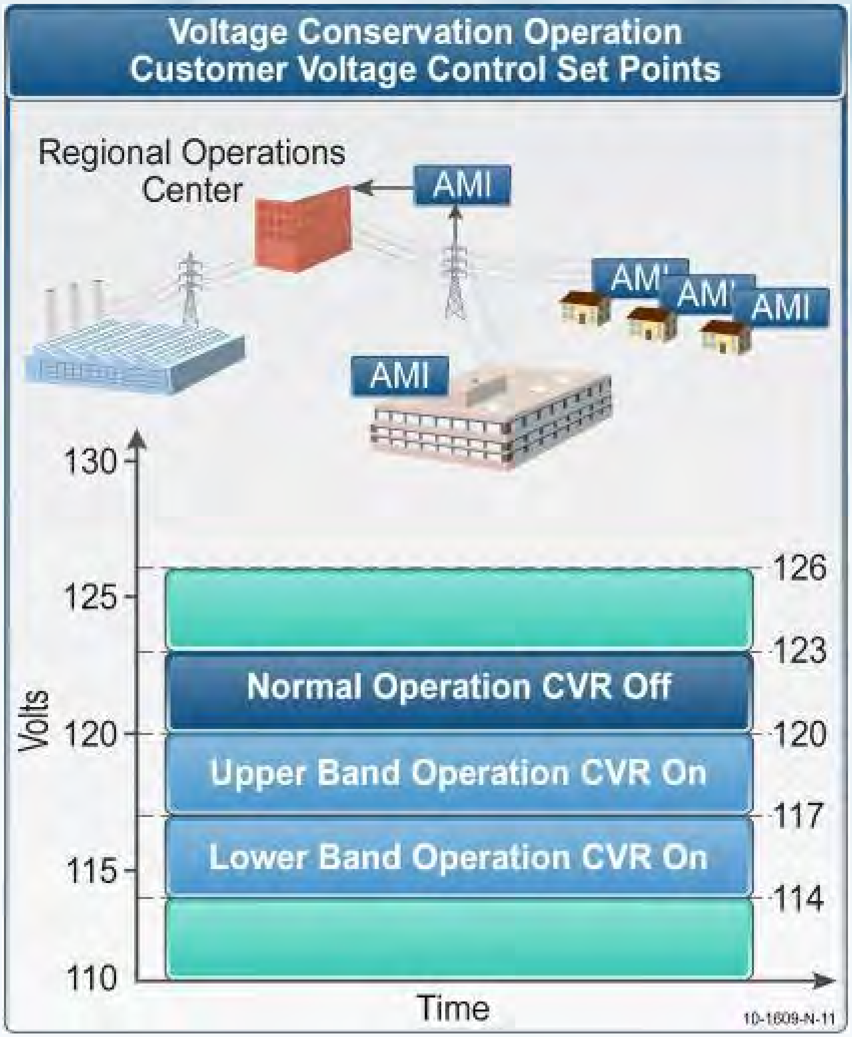
without negative customer impacts

Voltage Optimization – Not a new concept !



1. Band Edge Indicators
2. Voltage Bandwidth
3. Neutral Indicating Light
4. Voltage Level
5. Panel Locking Screw
6. AUTO/OFF/MANUAL Switch
7. RAISE/LOWER Switch
8. Motor Fuse
9. Panel Fuse
10. INTERNAL/EXTERNAL Power Switch
11. Voltmeter Terminals
12. External Power Terminals
13. Neutral Lamp Test/Drag Hand Reset Switch
14. Line Drop Compensator Control (polarity adjustment)
15. Resistance Volts, Line Drop Compensator
16. Reactance Volts, Line Drop Compensator
17. Time Delay
18. Operations Counter

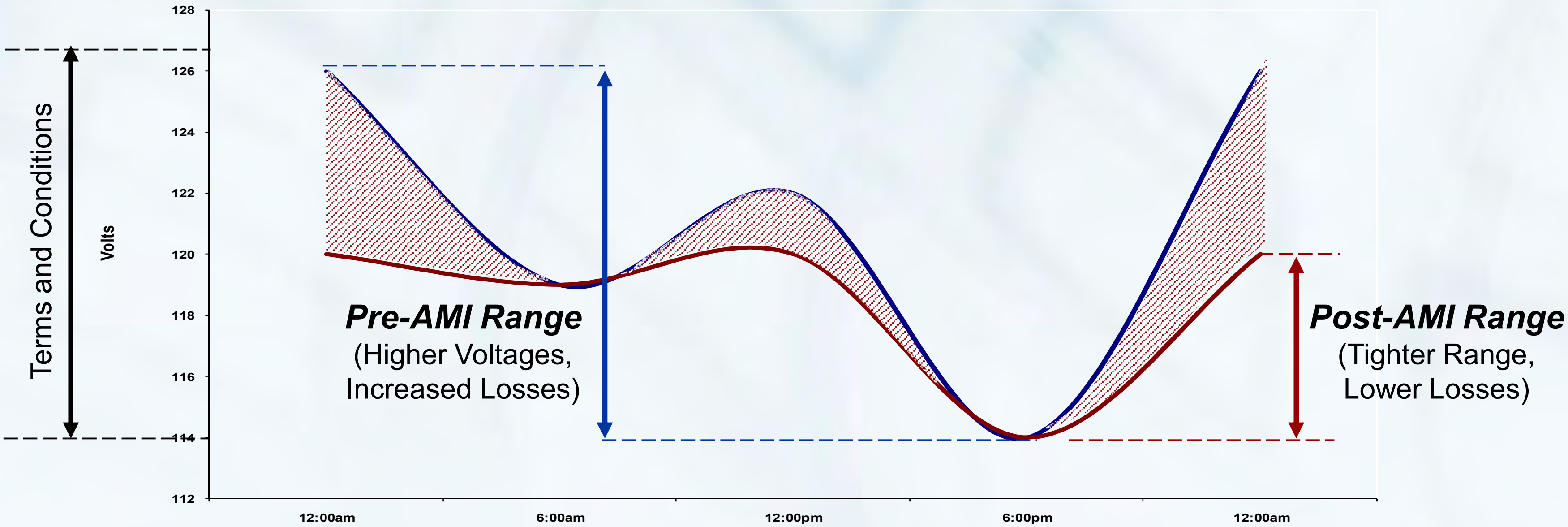
Voltage Optimization
(a.k.a. Conservation Voltage Regulation = CVR)



- Reduces energy consumption, demand and reactive power requirements (kWh, kW, and KVar) by reducing service voltage to the low half of the ANSI 84.1 range (114-126 Volts)

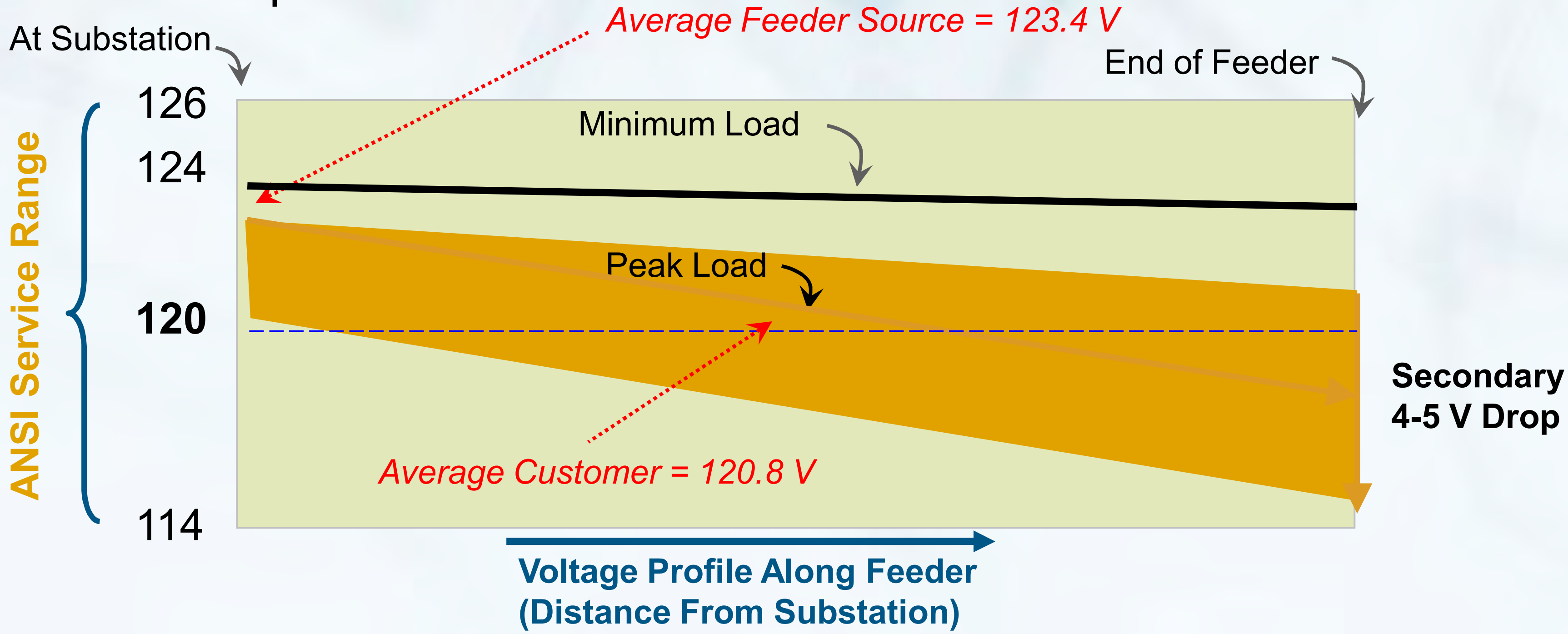
Conservation Voltage Regulation (CVR)

- AMI provides voltage and energy data to monitor and adjust voltage
- Conservation is achieved through avoided energy imports and behind-the-meter savings
- High confidence level of savings without depending upon customer actions



Voltage Optimization
Typical Practice without DE or VO

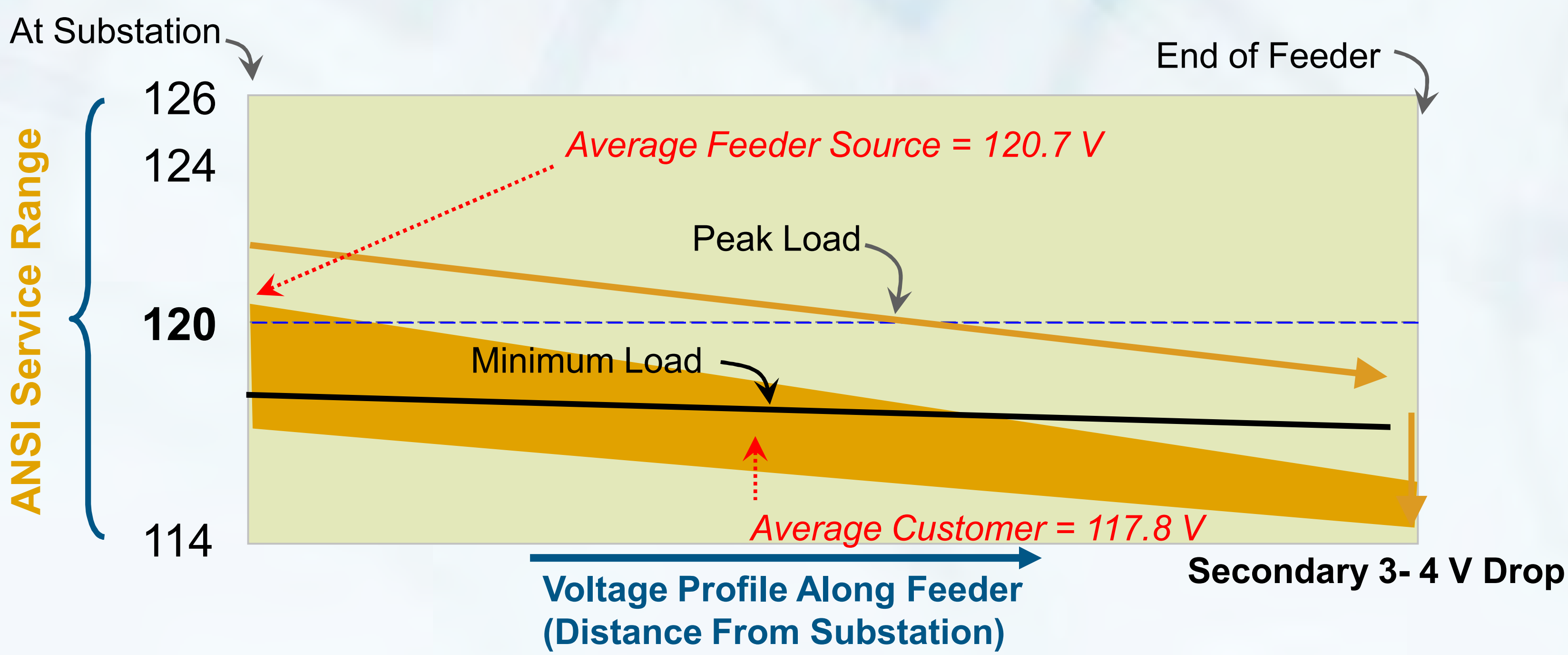
- High fixed voltage at substation
- Voltage at end of line varies with load
- At peak load 6 to 8 V drop on a feeder
- Transformer and service drop to customer additional voltage drop
- System average voltage is in upper end of ANSI range



SCH2

Voltage Optimization
Energy Savings ~ 2% to 3%

- Distribution system improvements flatten voltage profile
  - 4 - 6 volt drop on primary feeder
- Line drop compensation lowers and raises the voltage at the substation with load
- *Average system voltage is reduced*



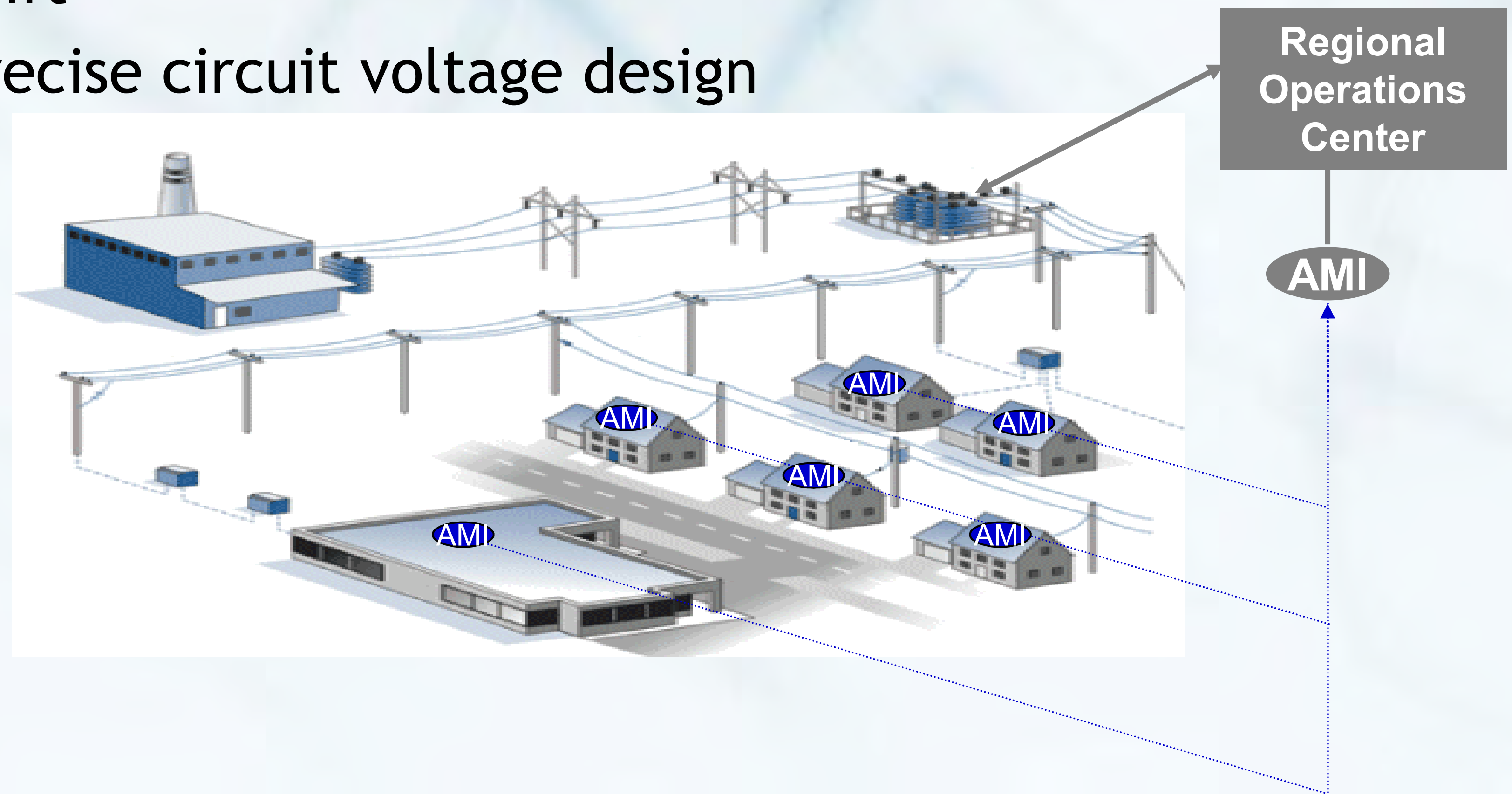
Slide 26

SCH2 What is the blue area? What is the black line? Why is this different from the previous illustration? Why is "At Substation" in a different location than on the last illustration? Is the "Average = 117.8 V" at the middle of the feeder? Or is that the average customer voltage over the whole feeder (the arrow inidcates it's at the middle)? Why does minimum load result in a lower voltage than maximum load (opposite of previous slide)?

Stephen C. Hadden, 3/21/2010

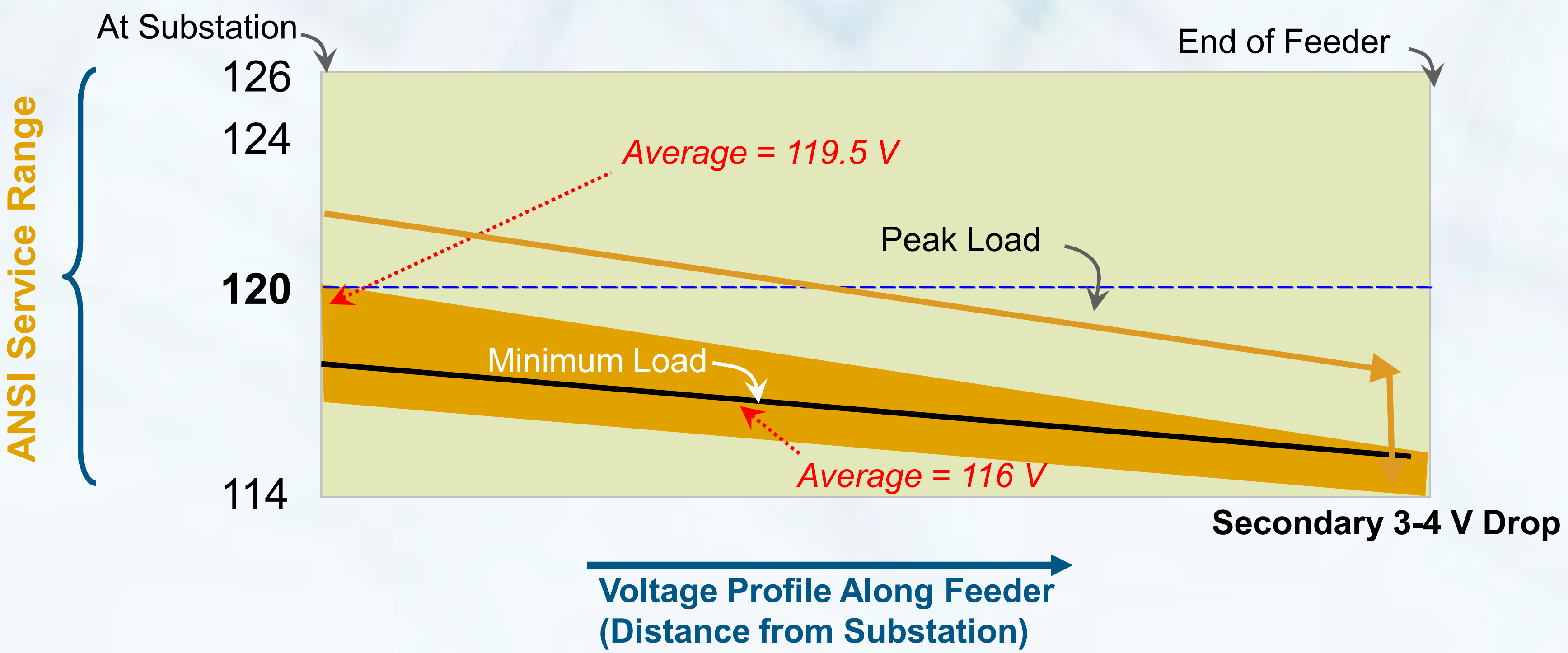
Voltage Optimization
Coupled with AMI

- Accurate measurement of customer voltage
- Accurate measurement of energy savings from voltage shift
- Precise circuit voltage design



Voltage Optimization with AMI
Energy Savings ~ 3% to 5%

- System improvements resolve low voltage areas identified by AMI data
- Safety margins reduced - voltage levels are know through system
- Average system voltage is reduced by an additional 1% to 2%



Northwest Energy Efficiency Alliance CVR Results

Summary of Voltage and Energy Results

Project	Voltage Reduction (ΔV)	CVR_f ($\%\Delta E/\%\Delta V$)	Project Energy Savings (MWh)[1]	Percent Energy Savings
Load Research	5.2 V (4.3%)	0.569 [2]	87	2.15%
Pilot Demonstration	3.03 V (2.5%)	0.69	8,476	2.07%

- Project Savings 8,563 MWhr (1.88 MW annually)
- 345 kWhr per residential home annualized (Load Research project)
- Cost for Majority of Pilots of less than 5 Mills (Mills = $0.001/kWhr)

CVR –Distribution Efficiency Measures

- Using AMI data to balance loads across phases
- Use data for VAR management
- Install voltage regulators along long feeders
- Reconductor to reduce losses
- Break existing overloaded feeder up with new feeder fed from new substation position

Distribution Automation

- Automated Capacitors
- Electronic Reclosers
- Line Voltage Regulators
- Automated Sectionalizing
- Self-Healing teams
- Lines Sensors

Improved Capacitor Controls

- Improve reactive support (voltage stability)
- Move from no control or time based to Voltage based

Capacitor Control

- Benefits of Smart capacitor control
  - Reduce VARs
  - Increase available T&D capacity
  - Reduce losses
  - Stabilize voltage
- Greatest value for utilities that have:
  - Fixed or time or temperature controlled capacitors
  - Heavy reactive load
  - Avoid power factor penalties

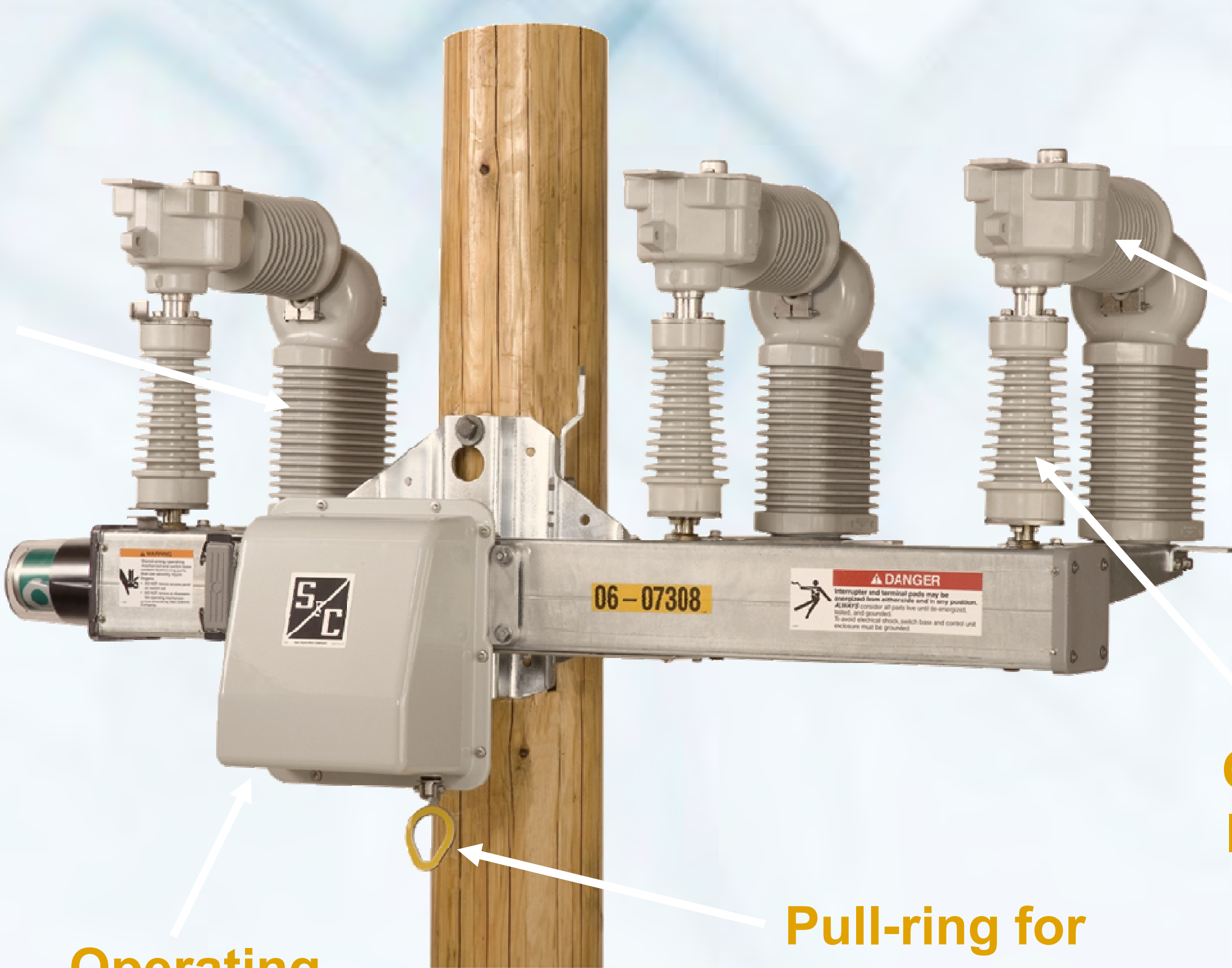
Automated Reclosers

- Sectionalizing with SCADA and DA
- Pulse reclosing – tests for presence of a fault prior to untested reclosing

Line Regulators

- Similar benefit as with substation
- Closer to load center

Automated Sectionalizing -SCADA Mate CX Switch

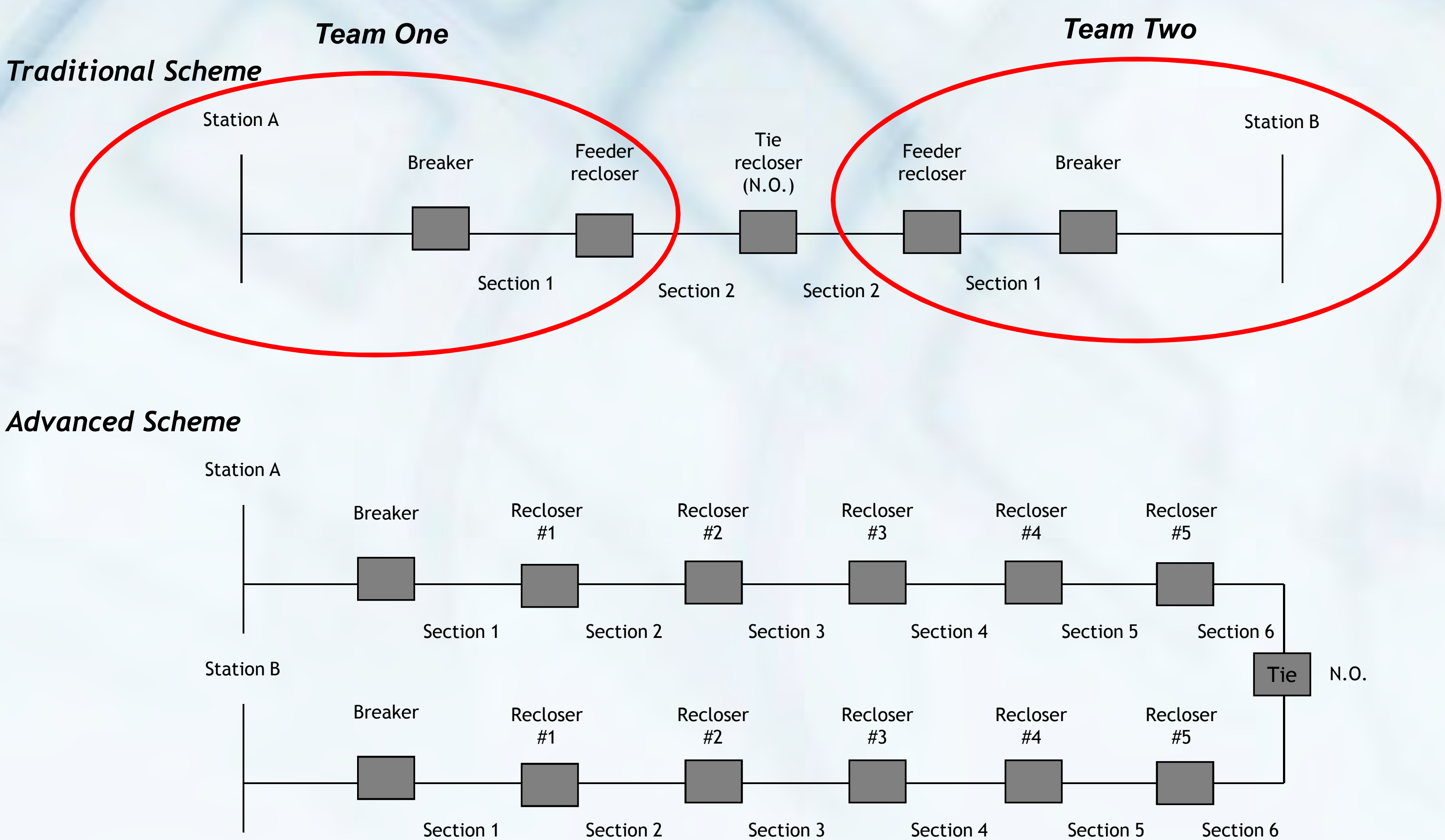


S&C Remote Supervisory Pad-Mounted Gear

Automated Sectionalizing

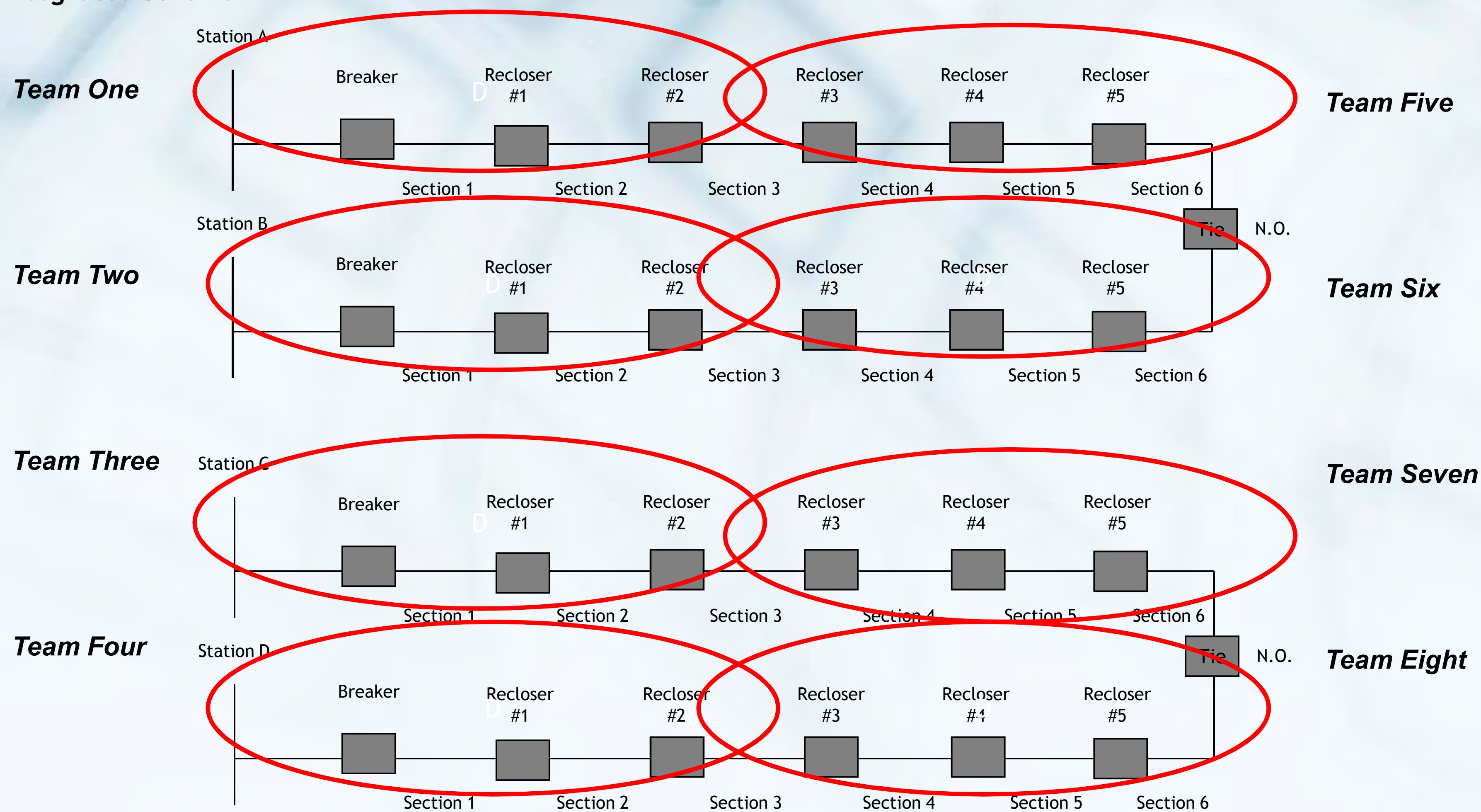
- Reconfigures feeder by switching
  - Isolates faulted line segment(s)
  - Restores supply to un-faulted segment(s)
  - Practiced for decades in high value situations
- New automation extends automated sectionalizing to more locations
  - Better response to diverse load / fault conditions
- Benefits not typically quantified in business case

Self-healing T&D systems



Self-healing T&D systems

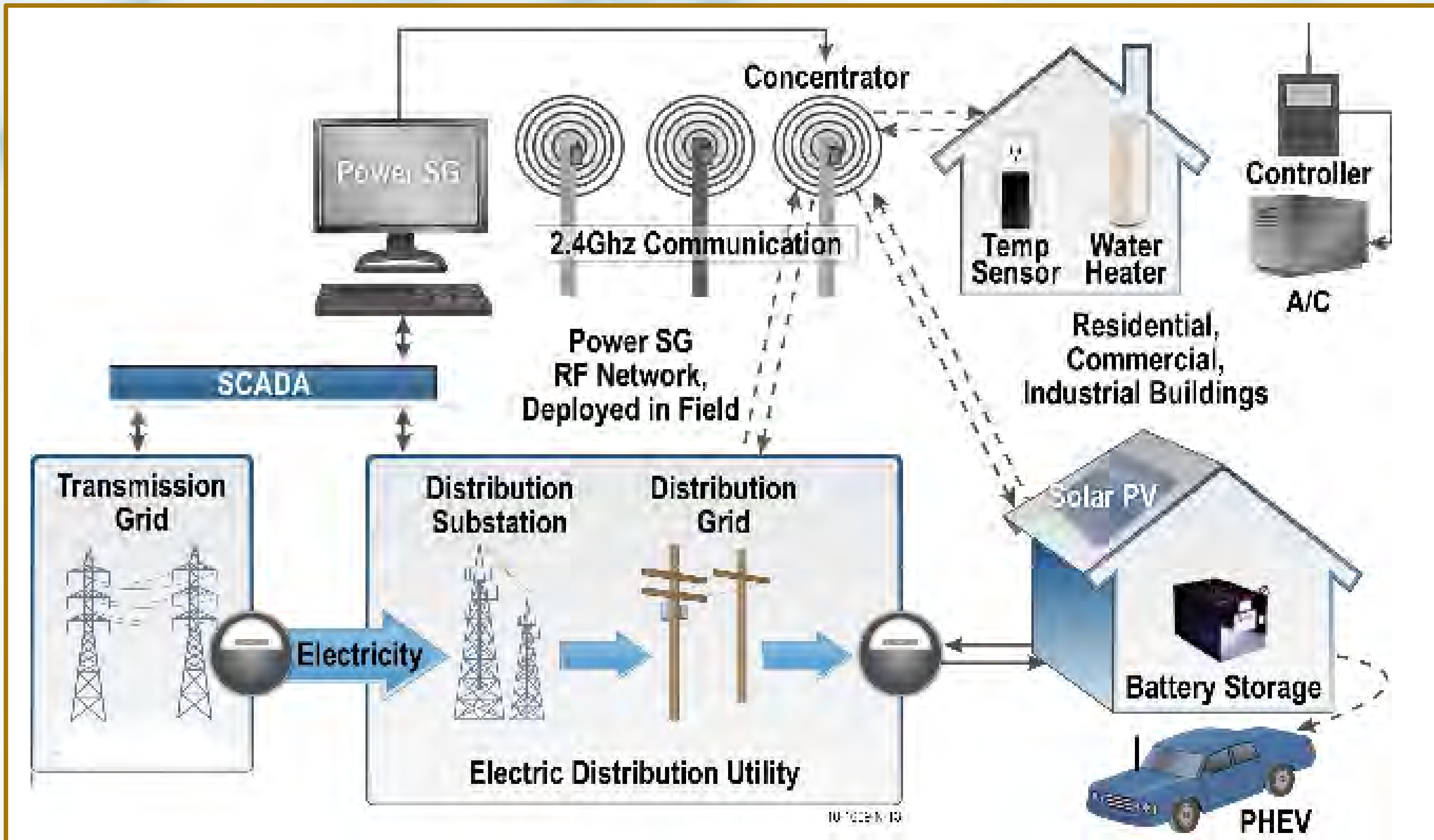
Integrated Scheme



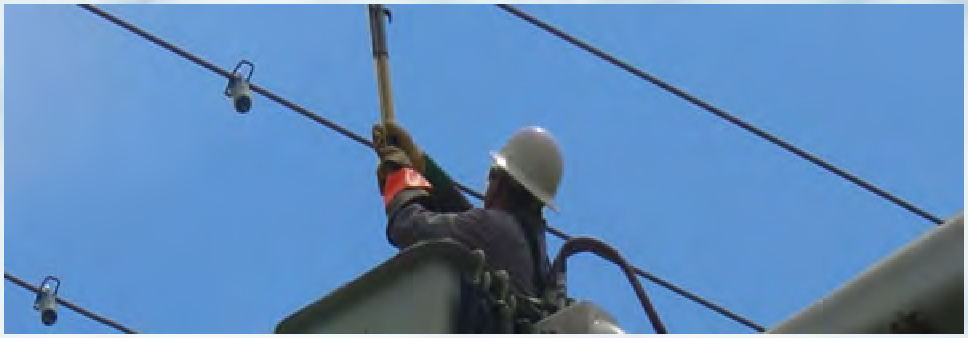
Centralized vs Decentralized Control

- Supervisory control
- Data model
- Restoration times(delays in dispatcher operated)
- Programming logic upgrades
- Software upgrades
- Adaptive learning – ability to look upstream
- Cost

DA Architecture



Line Sensors



- Fault Indication
- Monitor voltage, current, power quality
- Improve feeder balancing
- Reduce losses

More Efficient Circuits

- Predictive Analytics – Fault Location, Failure prevention
- Phase Balancing
  - Reduced Capital Expenditures
  - Reduced Losses
- Transformer "Right Sizing"
  - From more accurate load data
  - Fewer No-Load losses
- Increased Load Factors
  - Critical Peak Pricing
  - Demand Response

Power Quality monitoring

- Leveraging sensors to measure voltage & current wave forms
- Using system data model, with powerflow software to analyze:
  - Harmonics
  - Transient Stability
  - Voltage Support & Stability
- Installation of mitigation equipment to resolve disturbances

Advanced Asset Utilization

- Leverage AMI data to improve Transformer Load Management
- Other Predictive Analytics – (i.e., temperature of XMFR oil to determine if cooling fans are working).

DA Cost/Benefit

Costs

- DMS System - ~$500k
- DA (2 feeders) - ~$120k – reclosers, mid-point sectionalizing devise, IEDs, data concentrators

Benefits

- Improve reliability, reduces losses, reduce operations costs

Pitfalls to Avoid

- Communication standards between devices are many (some are propietary)
- Future communication standards (ie., IEC 61850)
- Not understanding the capabilities of existing & new equipment

Contact Information

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