



Power System
Engineering, Inc.



Distribution Automation & Substation Modernization

Benefits & Steps to a Successful Implementation

Jim Weikert
Power System Engineering, Inc.

www.powersystem.org

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Benefits of Distribution Automation (DA)

DA Program Types	Improved Reliability	Improved Performance Indices	Increased Profit	Reduce Losses	Improved Asset Life
Smart Switching					
Conservation Voltage Reduction (CVR)					
Power Factor Improvement (VAR)					
Real-time Fault Indicators					

Reliability & Performance Metrics

- **Voltage Sags:** Can cause under-voltages that can disrupt manufacturing processes.
- **Harmonics:** Decrease equipment life; increase line losses.
- **Spikes:** Severe over-voltage for very short periods can damage electronic equipments.
- **Phase Imbalances:** Increase system wide losses, damage equipments and machinery.
- **Customer Outage Metrics**

SAIDI	Sys. Avg. Interruption Duration Index	Duration of all interruption in sys / # customers
SAIFI	Sys. Avg. Interruption Frequency Index	Number of interruptions in sys / # customers
CAIDI	Cust. Avg. Interruption Duration Index	Average outage time (SAIDI/SAIFI)
MAIFI	Mom. Avg. Interruption Frequency Index	Number of blinks in sys / # customers

Utilities are serving the needs of digital society.

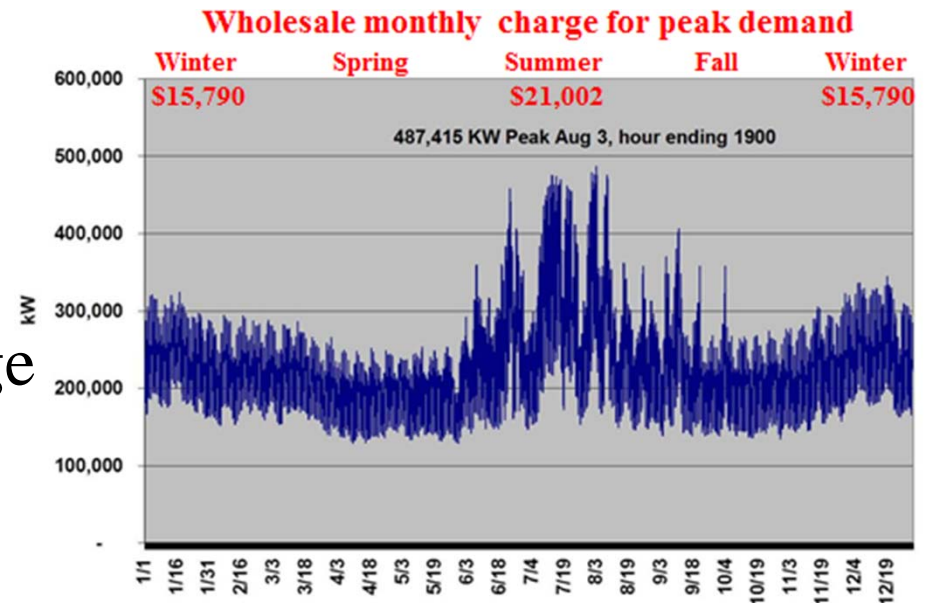
Volt/VAR Benefits

- Utilities face these issues every day
- A solid Volt/VAR scheme can improve or alleviate many of these.

Pain Points	Cause	Severity		VAR	CVR
PF Penalties	G&T charges for Lagging Power	\$\$	Penalties	✓✓	
Lost Capacity	Excess current due to inductive loads uses up line capacity.	\$	5-10% Excess Current	✓✓	✓
Line Losses	Resistance in wire uses Real power	\$	10-20% Excess Line Losses	✓✓	✓
Voltage Drop	Excess current and line loss leads to excess voltage drop	\$	5-10% Excess Voltage Drop	✓	✓
Lost Generation	Customers charged for W but Generation covers VA	\$\$\$	Unbilled Generation	✓✓	
Peak Penalties	Excess energy usage during coincident peak periods	\$\$\$	Peak Rates	✓	✓✓

CVR Case Study: Cost/ Benefit Analysis

- Midwest Suburban Co-op
- 140,000 Customers
(270 C&I, 10 large industrial)
- 40 substations, 400MW avg.
- Winter & Summer peak charge
6 coincident peaks/year



Program Results

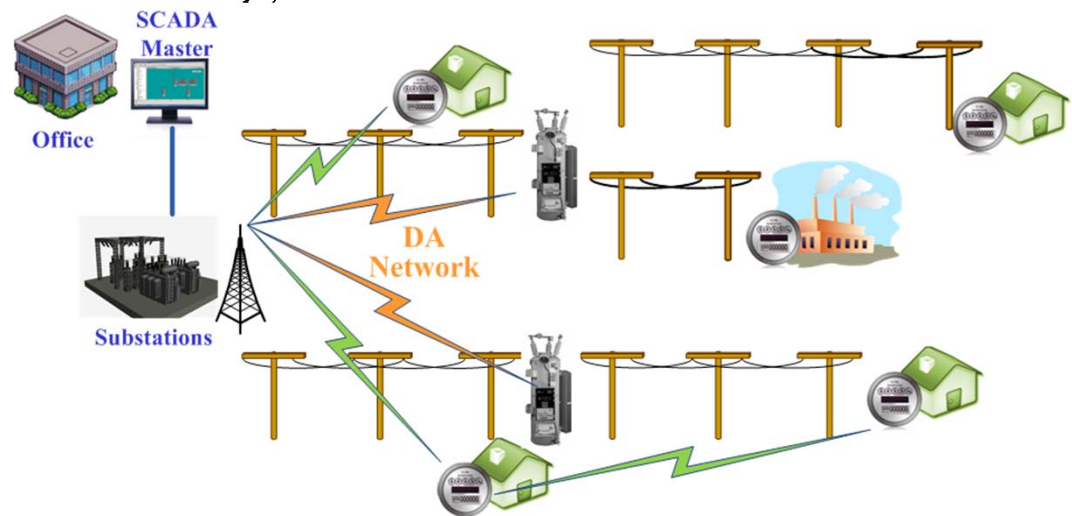
- 16 Substation Pilot (178MW Peak)
3.2MW (1.8%) reduction: VAR (flattening) & CVR (peaks only)
- 24 Substations Remaining (414MW Peak)
3.7MW (0.9%) conservative estimate: not all feeders,

Net Present Value (15 years)

- \$2.7M investment, \$370,000 annual benefit
- Positive present value of more than \$725,000 over 15 years

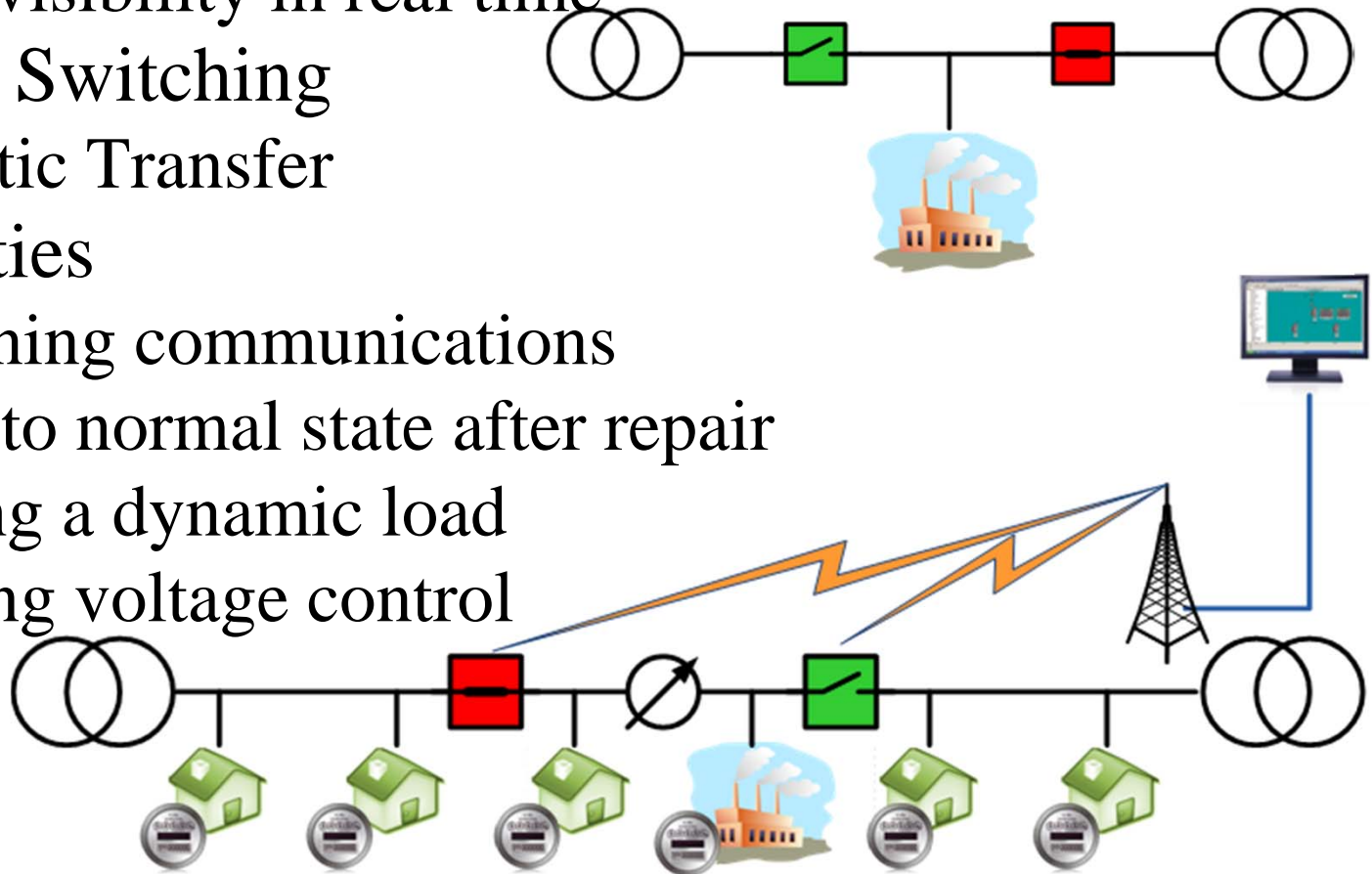
Voltage Control Program

- Components
 - Regulation (Substation & Feeder)
 - Measurement (Meters & Regulators)
 - Control (SCADA or Integrated Volt/VAR Application)
- Considerations
 - Objectives: CVR, Voltage Optimization
 - Seasonal / Daily Load changes
 - Metering latency
 - Dynamic network



Switching Program

- Implementation Options
 - Central / Distributed Control
 - Central visibility in real time
- Simplistic Switching
 - Automatic Transfer
- Complexities
 - Maintaining communications
 - Restore to normal state after repair
 - Modeling a dynamic load
 - Switching voltage control



Feeder Switching Example

Reliability is primary benefit (not simply cost justified)

Example Utility Profile:

- 10,000 customers
- 40MW Demand
- 15 Substations
- 50 Feeders

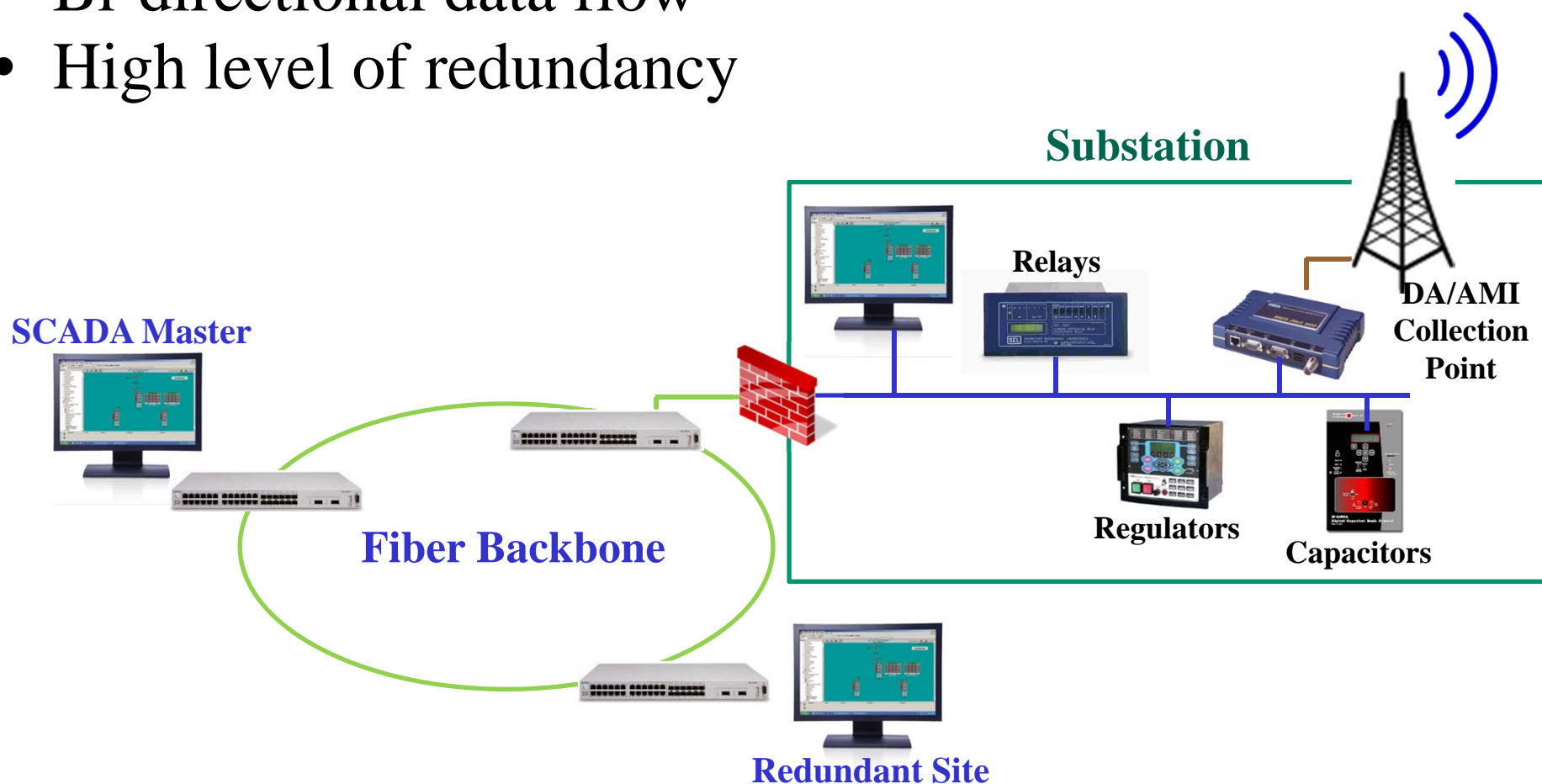
Assumptions:

- 2 Outages/Year (3 hours each)
- \$50,000 cost to C&I / outage
- 50% outage reduction with feeder switching

	Category	Item	Total
Cost	Equipment Cost	\$75,000	\$140,000
	Engineering & Labor	\$65,000	
Benefit	Customer Benefit	\$25,000	~\$25,000
	Revenue Recovered	Small	
	Fewer Truck Rolls	Small	

Modern SCADA Architecture

- Intelligent devices remotely accessible
- Bi-directional data flow
- High level of redundancy

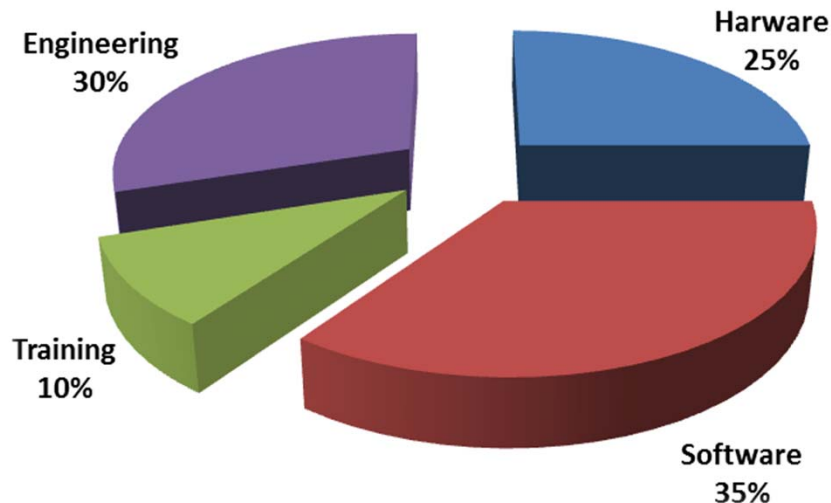


Modern SCADA Systems

SCADA System Components

- Software: License (features) & Maintenance
- Hardware: Servers, workstations, network, security
- Engineering: Database & screen design, site testing
- Training: User, upgrade and modification

Representative Cost Break-down



Features to consider:

- Redundant modular hardware
- Firewalls for secure remote access
- Open database for 3rd party integration
- Historian, Trending & Graphing
- Tagging for secure lockout
- User Authentication for access levels
- Web Access for infrequent users
- ICCP, MultiSpeak & protocol interfaces
- Security Logging for NERC CIP
- Advanced applications

Benefit to Many Departments

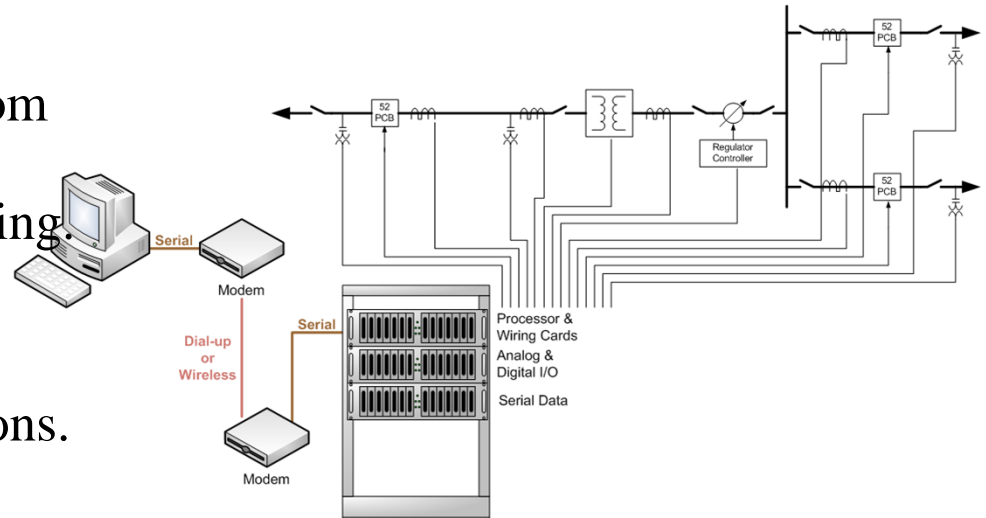
- Modern Substation Architecture is key to a well automated distribution system.

Function	Legacy Systems	Modern SCADA	Difference
Operations	<ul style="list-style-type: none"> • Customer reported issues 	<ul style="list-style-type: none"> • Continuous monitoring • Detect before fault 	<ul style="list-style-type: none"> • Better customer service
Routine Inspections	<ul style="list-style-type: none"> • Travel to every site • No info between visits 	<ul style="list-style-type: none"> • Gather remotely • Travel when needed 	<ul style="list-style-type: none"> • Less drive time • More information
System Protection Optimization	<ul style="list-style-type: none"> • Multiple trips to gather data, analyze and optimize 	<ul style="list-style-type: none"> • Obtain data remotely • Monitor changes 	<ul style="list-style-type: none"> • More efficient analysis • Better follow-up
Equipment Failure	<ul style="list-style-type: none"> • Dispatch, assess, get equipment, return, fix 	<ul style="list-style-type: none"> • Remotely analyze • First trip to fix 	<ul style="list-style-type: none"> • Faster repair time
System Engineering	<ul style="list-style-type: none"> • Limited system data • Tough to gather data 	<ul style="list-style-type: none"> • Real-time historical information & settings. 	<ul style="list-style-type: none"> • Better timely data • Better decisions & design updates

Role of the RTU

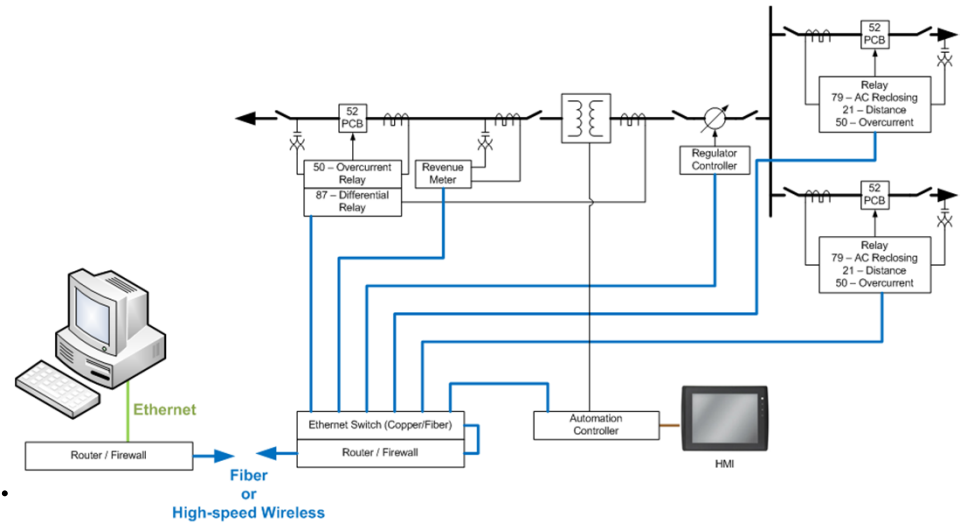
Legacy

- **Capture signals** (analog & digital) from transducers.
- **Data gathering** without decision making
- **Vendor specific** protocols
- Gather data from serial devices.
- **Constrained** by limited communications.
- **Limited history**, sequence of events.



Modern

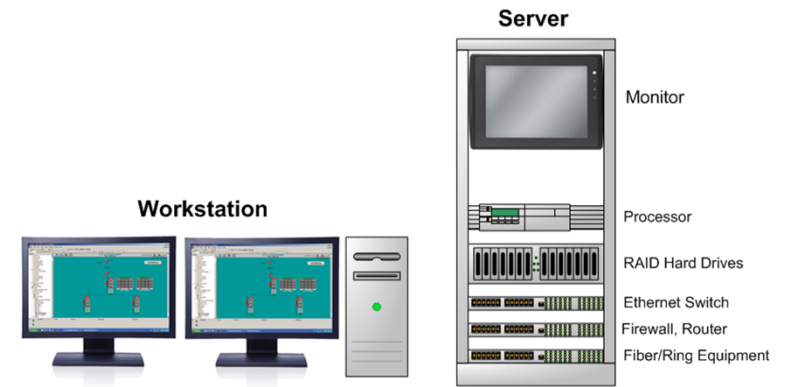
- **One of many intelligent devices.**
- **Data gathering** blended with decision making.
- **Standard (DNP3, 61850)** protocols.
- Gather data from legacy transducers & devices.
- **Enabled** by improved communications.
- **Greater history**, sequence of events.



Stages of Automation

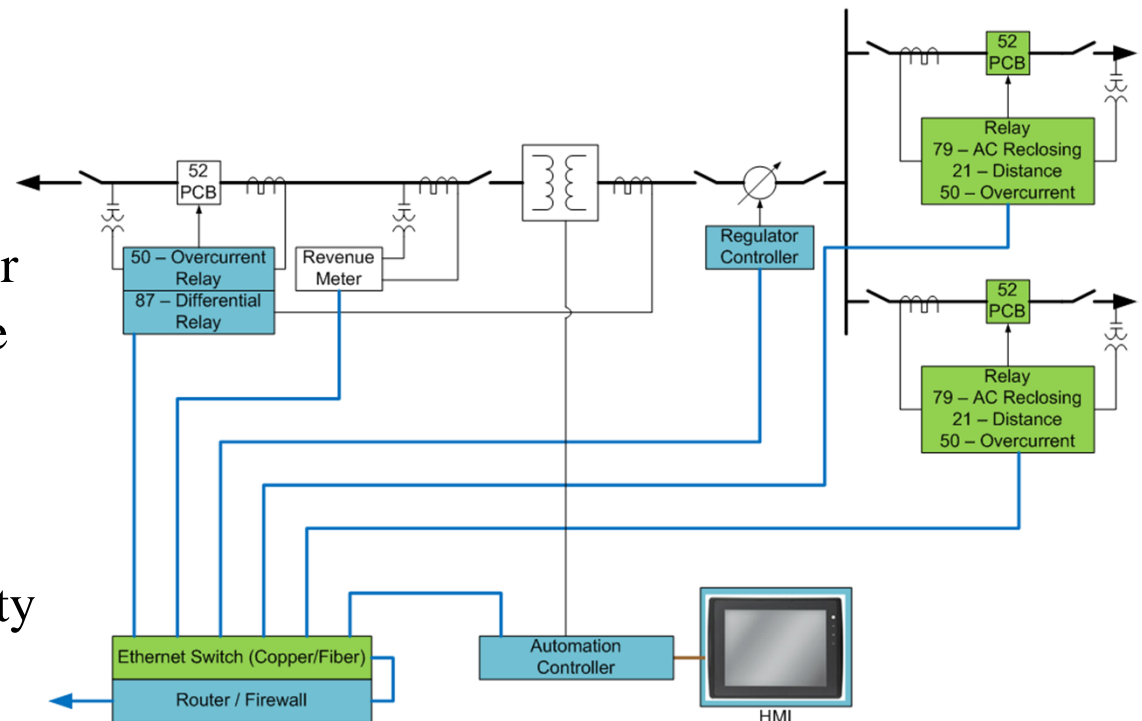
SCADA Master

- Powerful server
- Separate workstation(s)
- Monitoring and Control
- Alarm management, historian & trending



Substation Automation

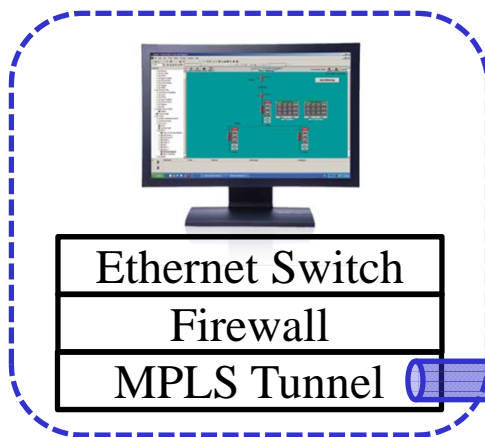
- Ethernet connectivity
- Bandwidth to SCADA master
- IED Reclosers: feeder outage notification, demand profile, control, sequence of events data
- Revenue meter: substation MVA, MW, PF, power quality data
- Standard RTU



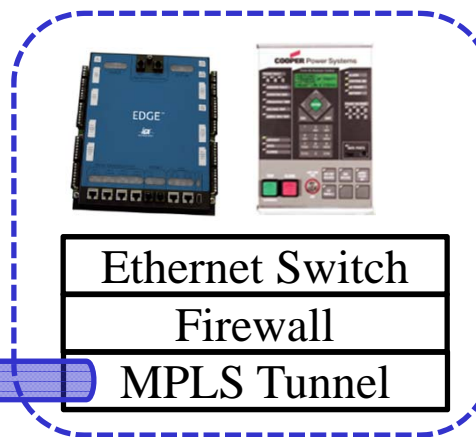
Role of Security in Modernization

- Prepare for Future, Apply best practices today
- Security essential for remote intelligence
 - Perimeter, Authentication, Encryption, Integrity)
 - Scale solutions, start with secure base

Electronic Security Perimeter



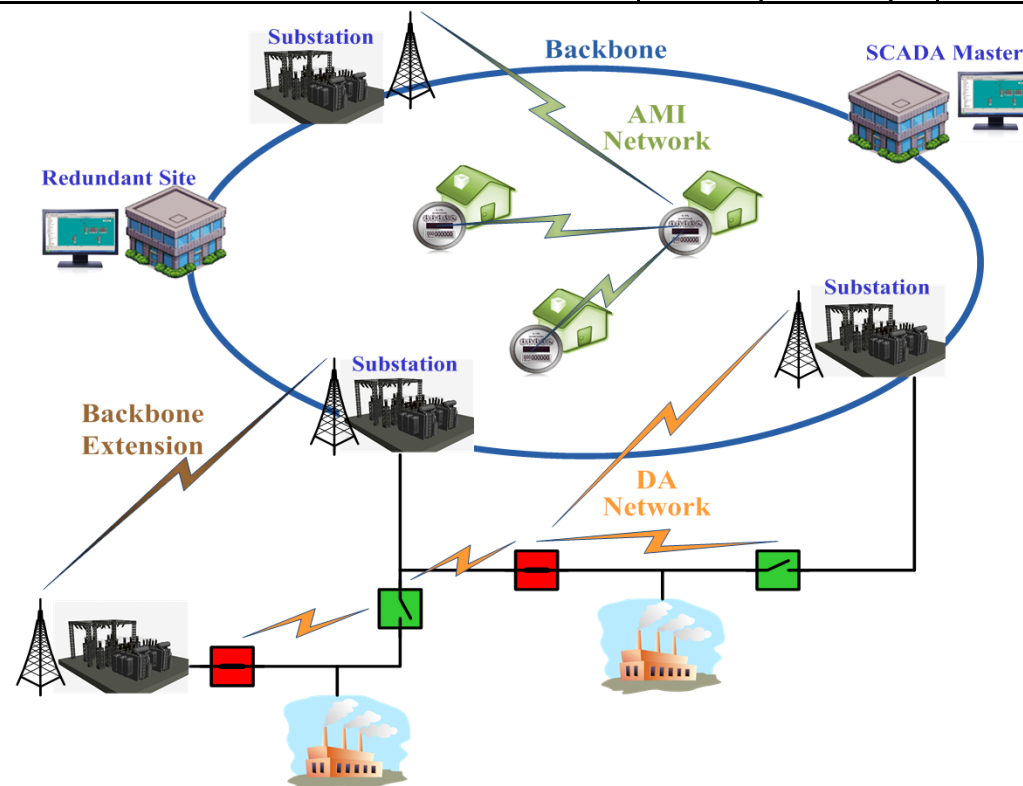
Electronic Security Perimeter



NERC CIP	Purpose
Version 3	Address fundamental Critical Cyber Assets
Version 4	Greatly expand the number of Bulk Electric System assets
Version 5	Complete coverage of FERC Order 706

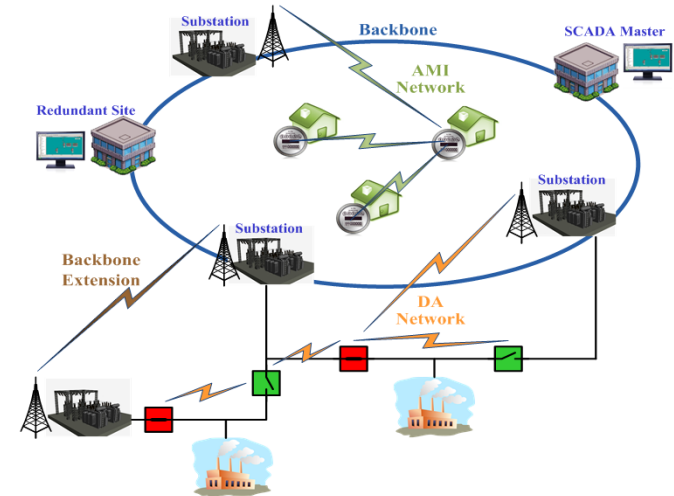
Multi-Tier Infrastructure

Tier	Description	Speed	Coverage	Redundancy
1	Backbone	High speed 10-100+ Mbps	Ring	Critical
2	Backbone Extension	Medium speed 10+ Mbps	Point to Point	Preferable
3	DA Network	Lower speed 30 kbps to 1 Mbps	Wide-area	Preferable
4	AMI Network	Lower speed <500kbps to 1Mbps	Wide-area	Preferable



Technology & Tier Comparison

- Each technology has its own strengths.
- Best solution is to use multiple technologies across tiers, matching the strengths with the requirements



Technology	Characteristics	Tiers			
		1	2	3	4
Fiber	Speeds to 10+ Gbps, Ring network supporting redundancy	✓✓			
Licensed Broadband Wireless (6, 11 and 18GHz)	Speeds ~ 10 to 150 Mbps Point to point links,	✓	✓✓		
Unlicensed Wireless	Speeds 1-10Mbps, Point to multipoint coverage, non-dedicated channels		✓	✓✓	
Licensed Wireless (220, 450 & 900MHz)	Speed ~10kbps Very good wide area coverage			✓✓	✓✓
Power Line Carrier	Speeds ~10kbps			✓	✓
Cellular	Speeds 1+Mbps, generally good coverage, uncontrolled reliability			✓	✓