

Power System Engineering, Inc.

PSE

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.

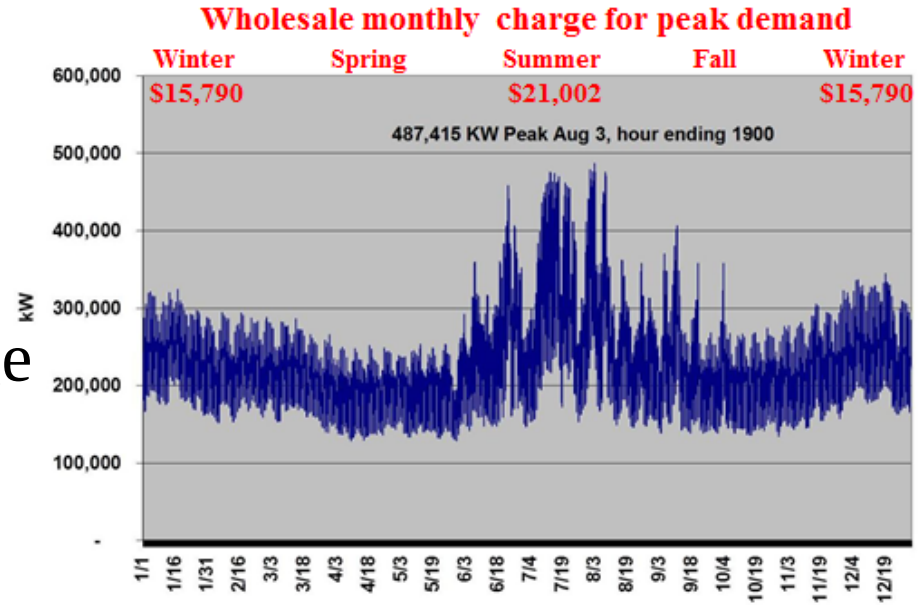
Volt/VAR Benefits

- 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

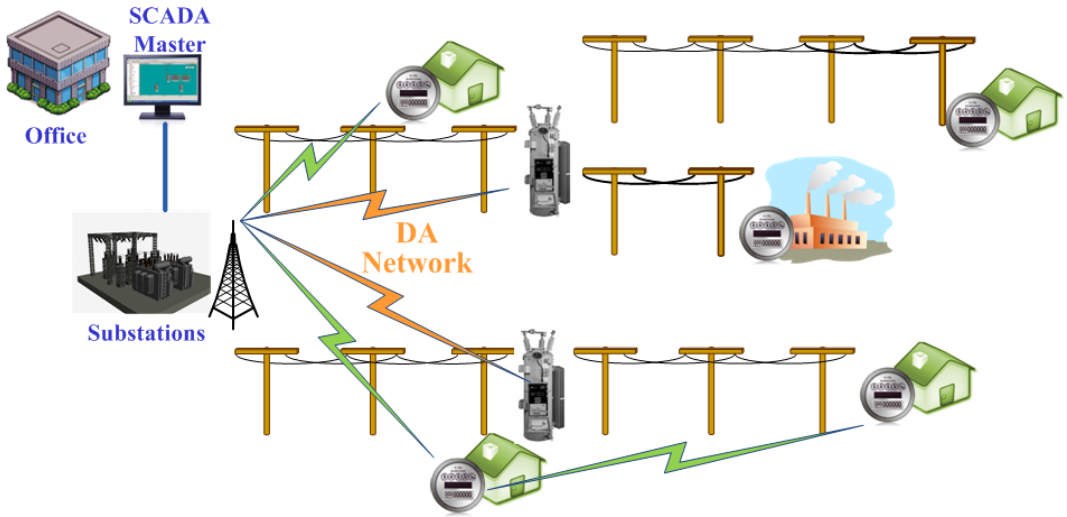
- 16 Substation Pilot (178MW Peak)
  3.2MW (1.8%) reduction: VAR (flattening) & CVR (peaks only)
- 24 Substations Remaining (414MW Peak)
  3.7MW (0.9%) conservative estimate: not all feeders,

Net Present Value (15 years)

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

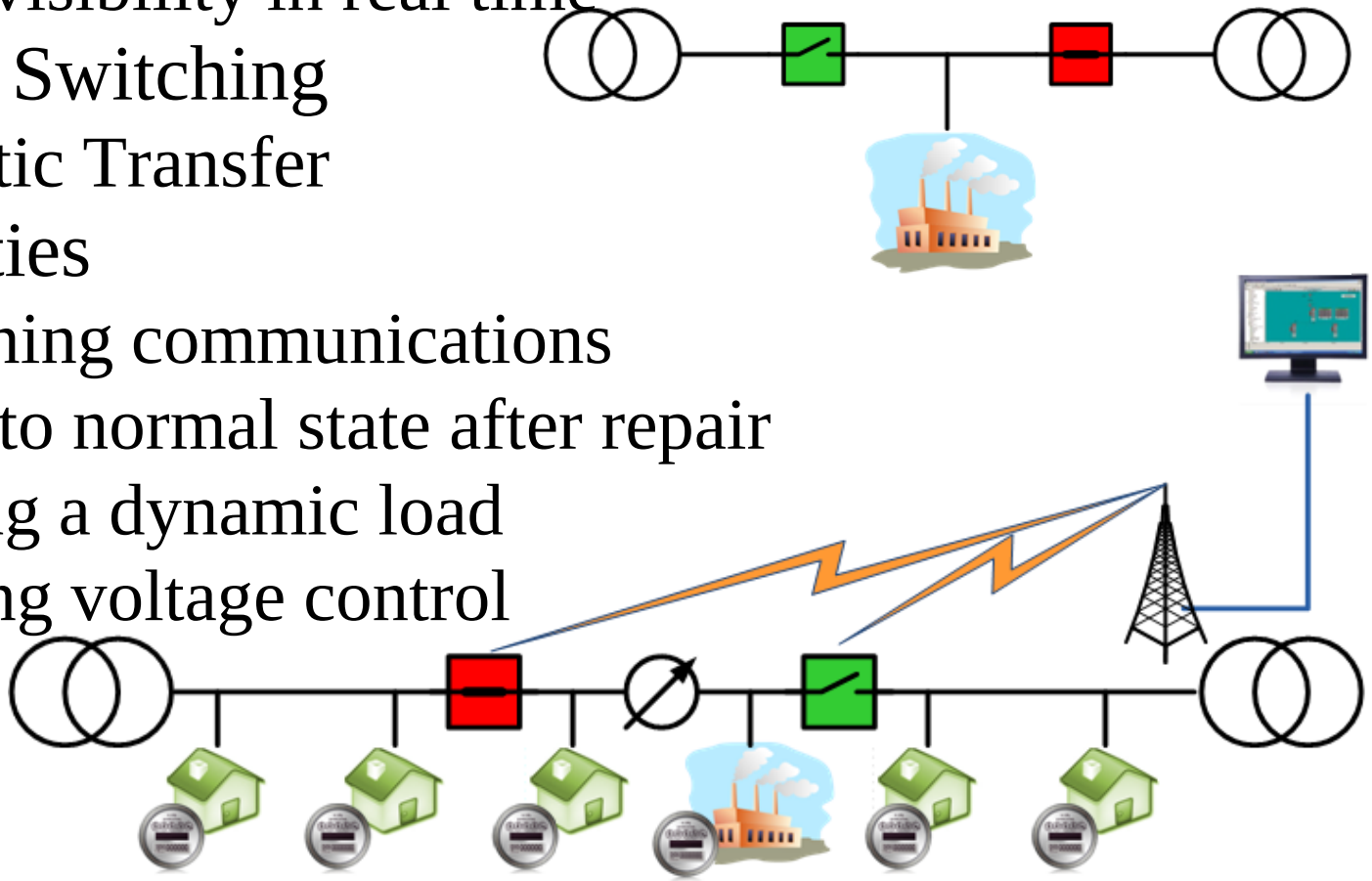
Voltage Control Program

- 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

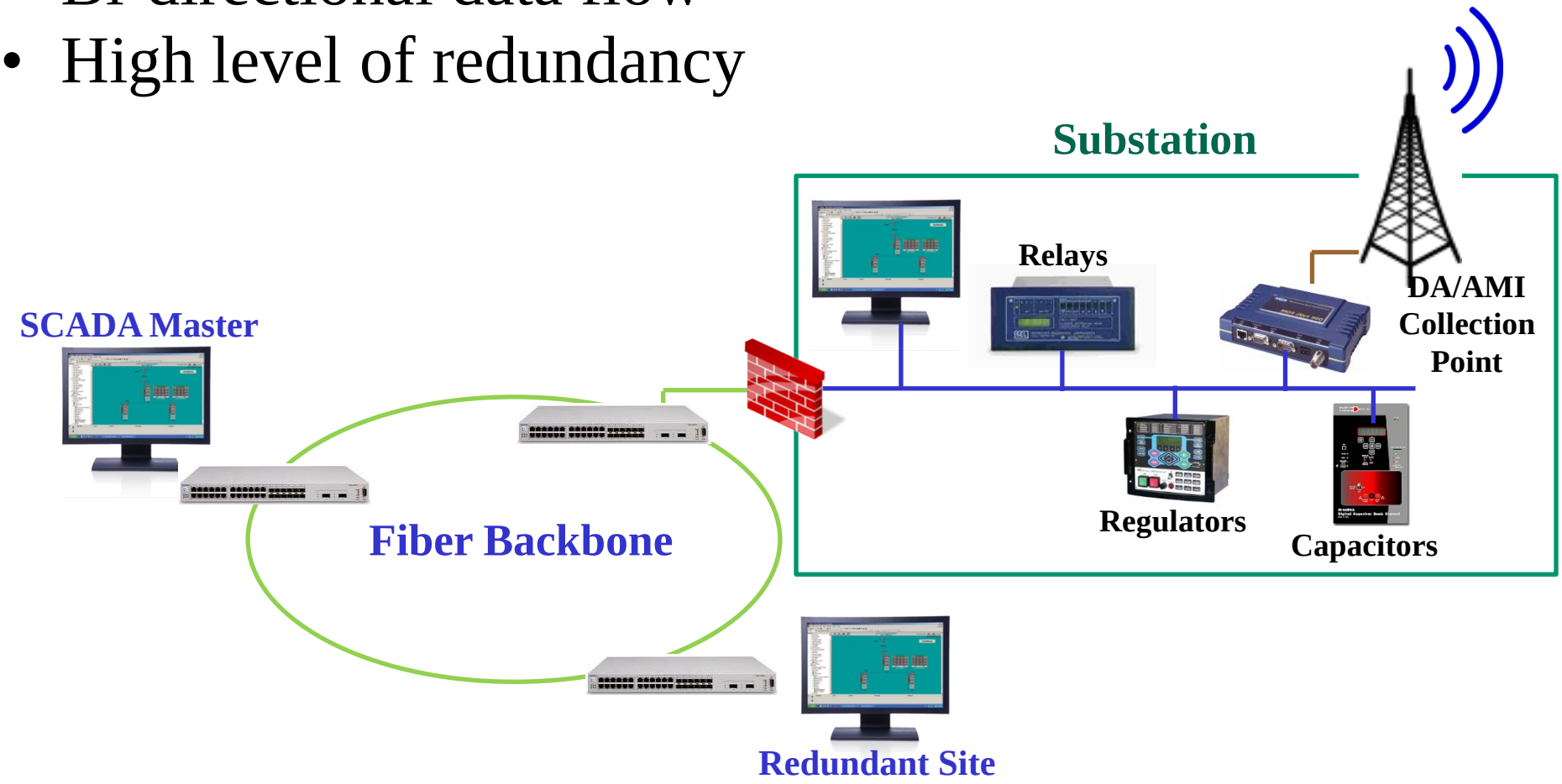
Assumptions:

- 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

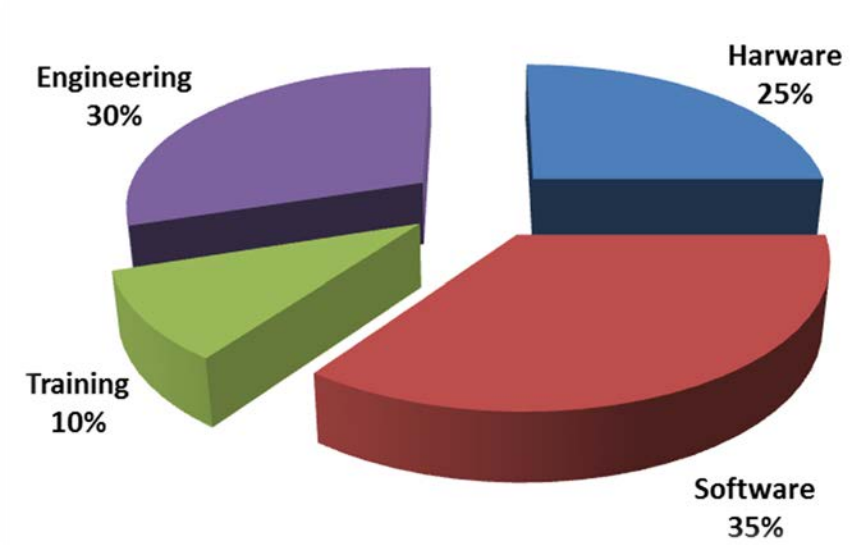


Modern SCADA Systems

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

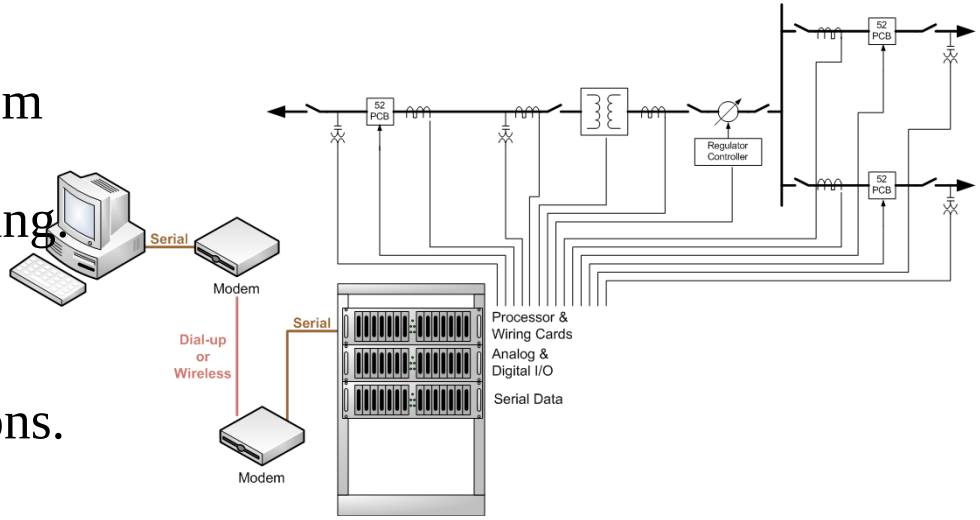
- Modern Substation Architecture is key to a well automated distribution system.

Function	Legacy Systems	Modern SCADA	Difference
Operations	• Customer reported issues	• Continuous monitoring • Detect before fault	• Better customer service
Routine Inspections	• Travel to every site • No info between visits	• Gather remotely • Travel when needed	• Less drive time • More information
System Protection Optimization	• Multiple trips to gather data, analyze and optimize	• Obtain data remotely • Monitor changes	• More efficient analysis • Better follow-up
Equipment Failure	• Dispatch, assess, get equipment, return, fix	• Remotely analyze • First trip to fix	• Faster repair time
System Engineering	• Limited system data • Tough to gather data	• Real-time historical information & settings.	• Better timely data • Better decisions & design updates

Role of the RTU

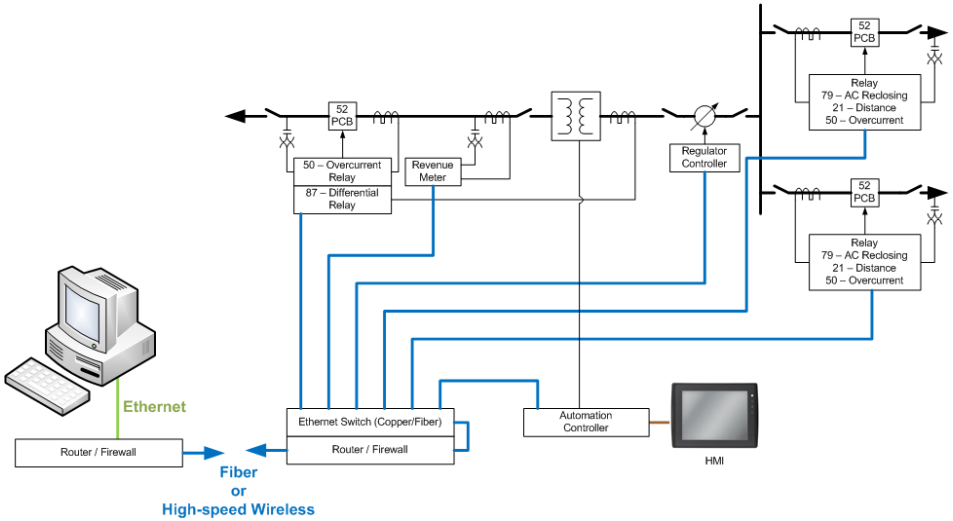
Legacy

- **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

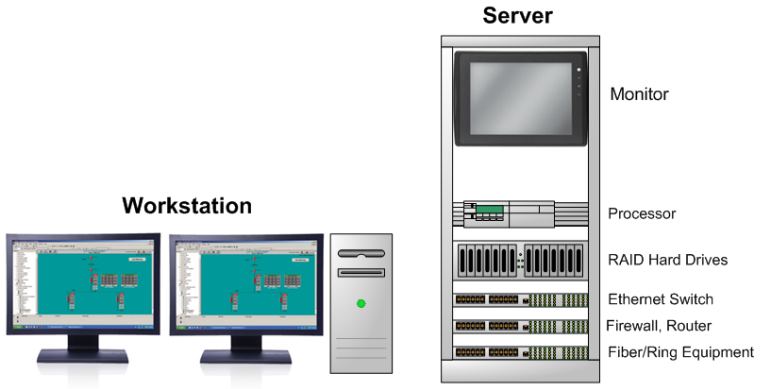
- **One of many intelligent devices.**
- **Data gathering** blended with decision making.
- **Standard (DNP3, 61850)** protocols.
- Gather data from legacy transducers & devices.
- **Enabled** by improved communications.
- **Greater history**, sequence of events.



Stages of Automation

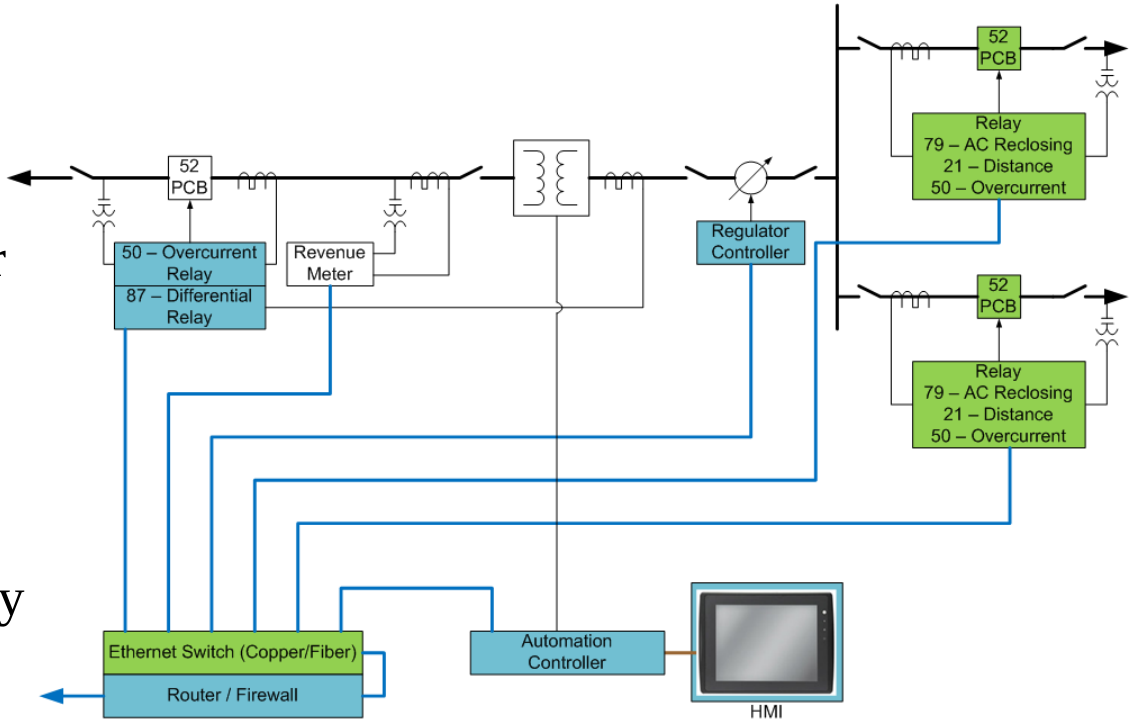
SCADA Master

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



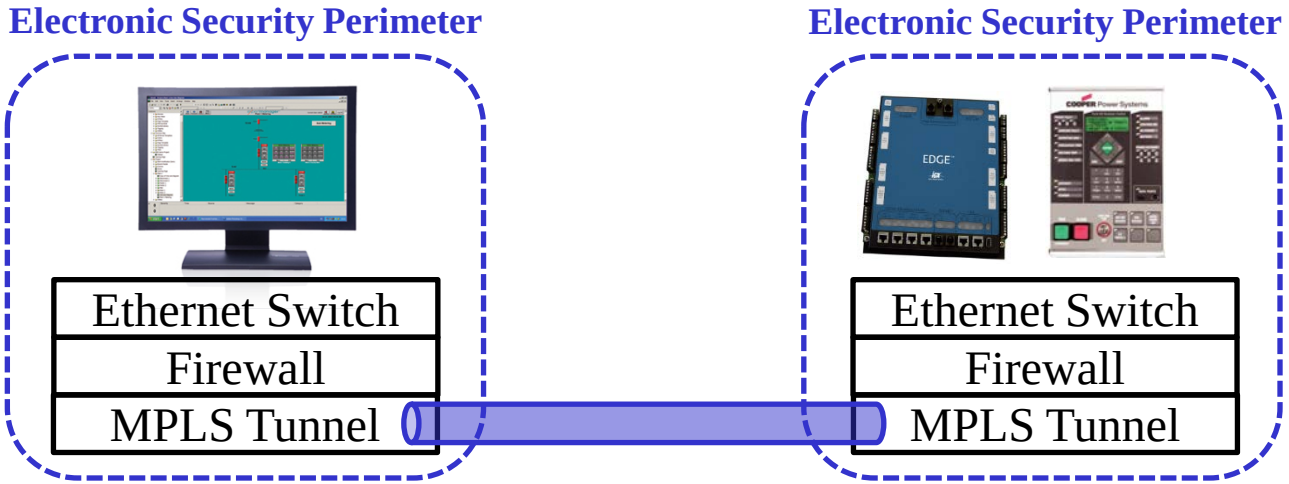
Substation Automation

- 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

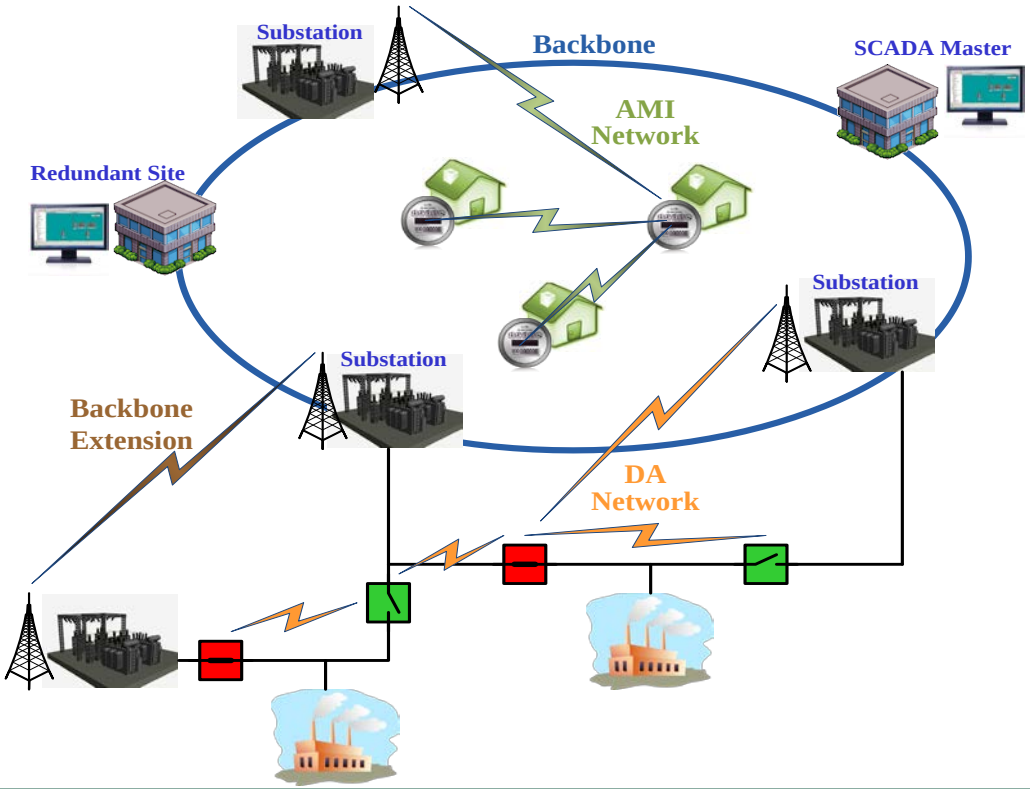
- Prepare for Future, Apply best practices today
- Security essential for remote intelligence
  - Perimeter, Authentication, Encryption, Integrity)
  - Scale solutions, start with secure base



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

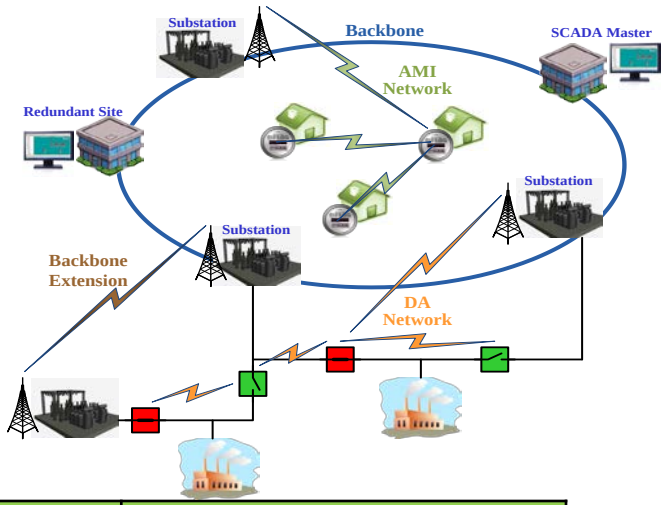
Multi-Tier Infrastructure

Tier		Description	Speed	Coverage	Redundancy
1	Backbone	Connect offices and most substations	High speed 10-100+ Mbps	Ring	Critical
2	Backbone Extension	Connects remote substations	Medium speed 10+ Mbps	Point to Point	Preferable
3	DA Network	Connect field DA equipment to each other and to a collection point to the SCADA system.	Lower speed 30 kbps to 1 Mbps	Wide-area	Preferable
4	AMI Network	Connect meters to each other and to a collection point.	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			✓	✓