CHALLENGES AND OPPORTUNITIES OF INTEGRATING SCADA SYSTEMS INTO SMALL HYDROELECTRIC CONTROL SYSTEMS

Control System Design Concepts
Design Approaches
Governor Controls
Redundancy
Implementation Strategies
Security Issues
Training Considerations

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What Is Small?

- The definition of a small hydro project varies
- Generating Capacity
  - Micro 0 – 100 kW
  - Mini 100 – 1000 kW
  - Small 1000 – 10,000 kW

Control System Design Concepts

- Legacy Hardwired Systems
- Remove Legacy Hardwired Control System and Replace with a new PLC/HMI Based Control System
- Hybrid (combination of Legacy Hardwired and PLC/HMI based systems)
- Remote Terminal Units (RTUs)

- Which is Best for Small Hydro?

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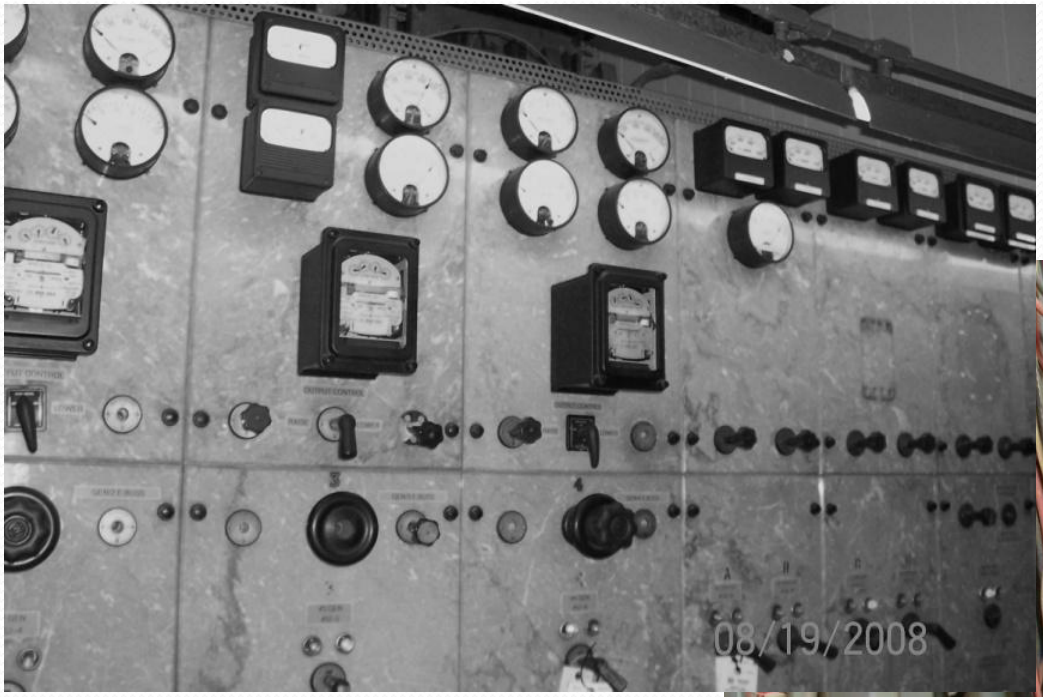
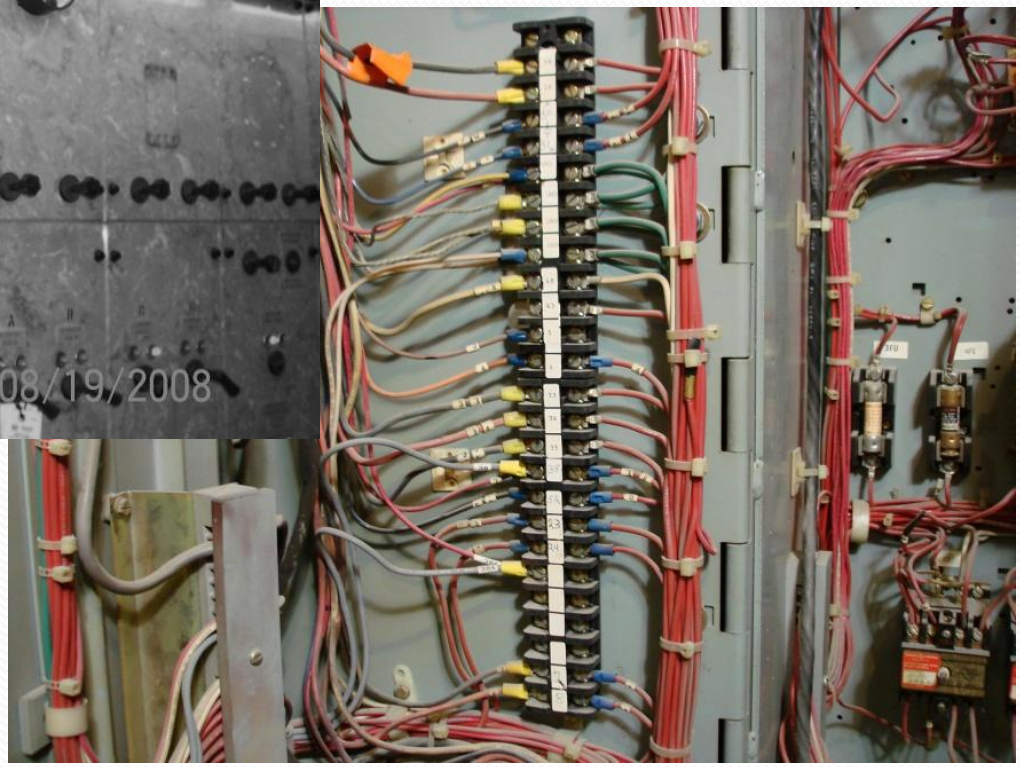
Legacy Hardwire Systems





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Legacy Hardwired System

- Advantages
  - Already in service
  - No upfront capital costs
- Disadvantages
  - Higher long-term operating and maintenance costs
    - Little operations/maintenance data
    - Harder to troubleshooting
    - More equipment to calibrate and maintain
  - Modern Operations
    - Lower efficiencies
    - Lower reactivity to system upsets
    - Harder to operate/monitor remotely

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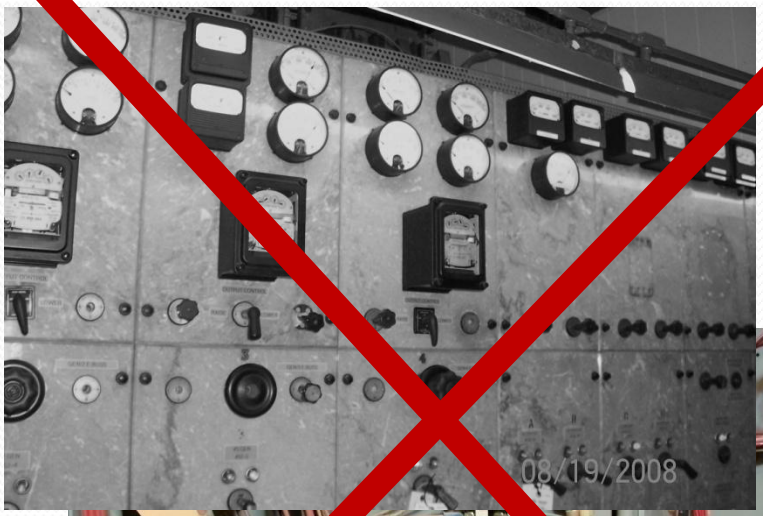
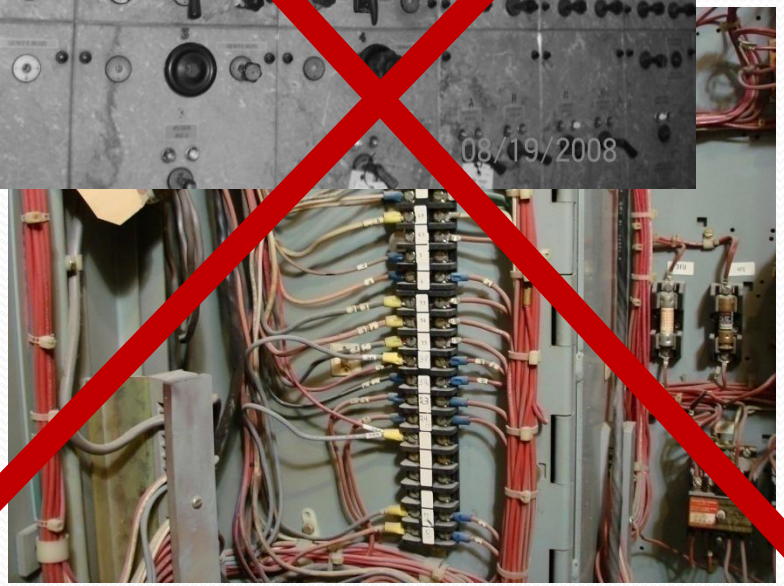
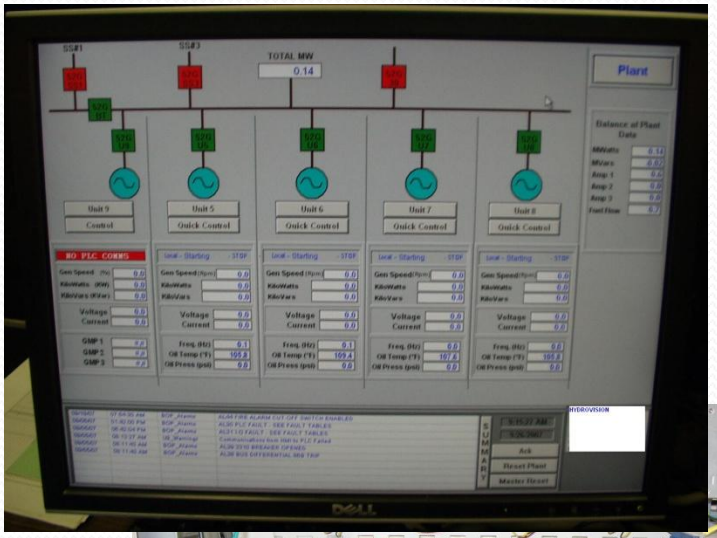
Remove Legacy System
Install PLC/HMI Based System







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Remove Legacy System Install PLC Based System

- Advantages
  - Less expensive to implement than Hybrid Systems
    - Less field work
    - Engineering is more straightforward
    - Less construction activities
  - Lower long-term operating and maintenance costs
    - Significant additional operations/maintenance data
    - Simplified troubleshooting and calibration activities
  - Modern operations
    - Additional efficiency
    - Significantly increases remote operation/monitoring

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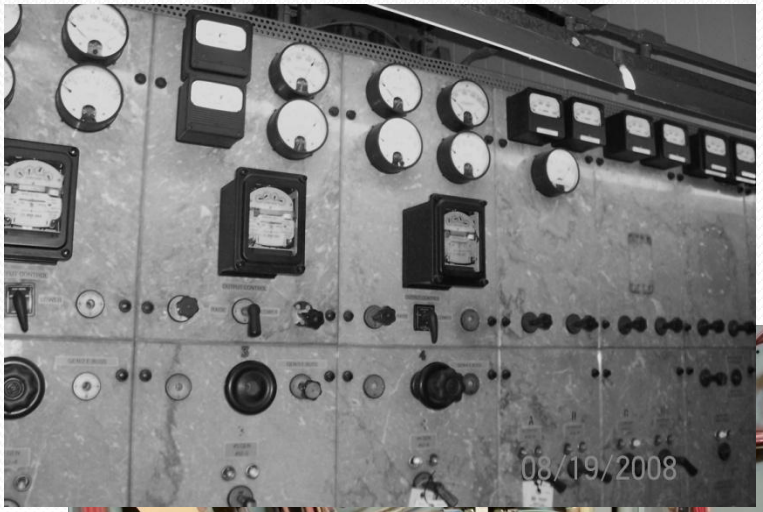
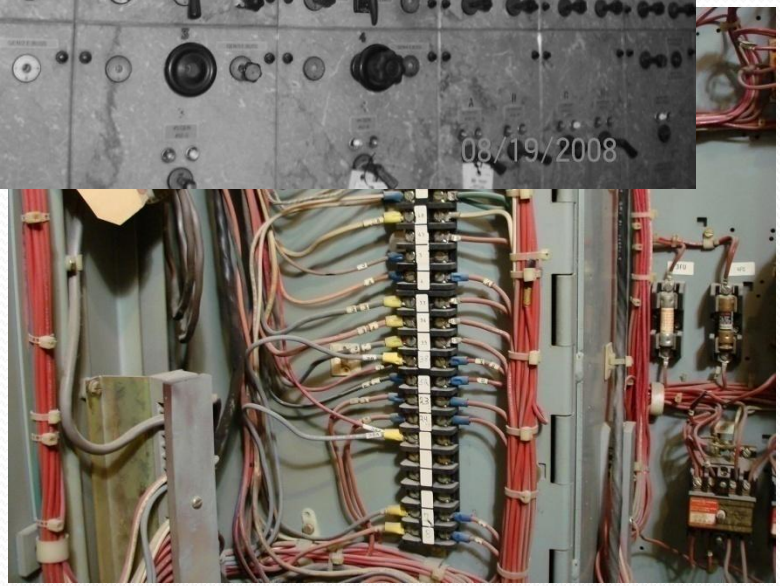
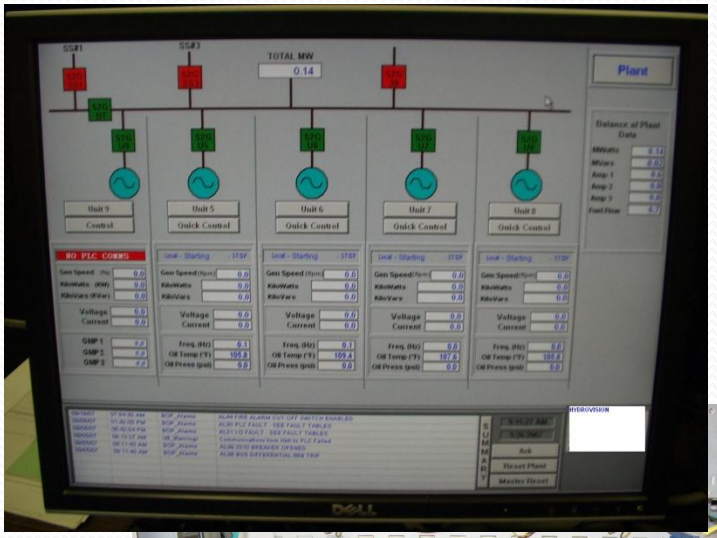
Remove Legacy System Install PLC Based System

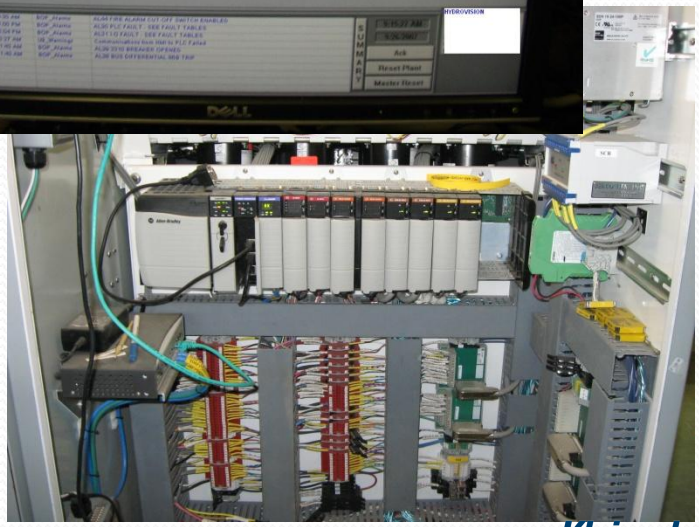
- Disadvantage
  - The biggest disadvantage is the loss of a hardwired "back-up" control system. If the PLC/HMI system malfunctions then the unit(s) is shutdown until the control system is repaired.
  - The loss of the "back-up" control system can be somewhat mitigated with redundancy design in the PLC/HMI system. However, this will increase cost and off-set any savings gained from not implementing a Hybrid system.

Maintain Legacy System
Install PLC/HMI Based System (Hybrid)









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Hybrid System

- Advantages
  - The biggest advantage with integrating the PLC/HMI based system with the Legacy system is the redundancy. If one system is down, the other will still function
  - Improved long-term operating and maintenance costs of Legacy systems
    - Significant additional operations/maintenance data
    - Simplified troubleshooting and calibration activities
  - Modern operations
    - Additional efficiency
    - Significantly increases remote operation/monitoring

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Hybrid System

- Disadvantages
  - Most expensive to implement
    - Significant field work
    - Engineering is more complicated
    - Increased construction activities
  - Requires legacy equipment to be calibrated and maintained

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Remote Terminal Unit (RTU)

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RTU

- Advantages
  - Low initial cost
  - Remote monitoring and control (limited)
- Disadvantages
  - Higher long-term operating and maintenance costs
    - Same as Legacy System, plus new RTU
  - Modern Operations
    - Same as Legacy System, except for limited remote monitoring and control.

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Control System Design Concepts

SYSTEM	INITIAL COST	OPERATING & MAINTENANCE COST	UNIT & PLANT CONTROLLABILITY
Legacy Hardwired	N/A	High	Low
PLC & HMI (only)	Medium	Low	Medium
Hybrid System	High	Medium	High
RTU	Low	High	Low

Small Hydro with Legacy Hardwired systems often benefit most from the RTU option due to the low initial cost and minimal gains in O&M and controllability.

New Small Hydro systems often benefit most from the PLC & HMI (only) option due to the savings from hardwired controls (distributed I/O) and gains in O&M and controllability.

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Design Approaches

- Distributive: PLC I/O throughout facility with distributed racks networked to the processor
- Centralized: PLC I/O hardwired to on common place where the PLC I/O racks and the processor are located

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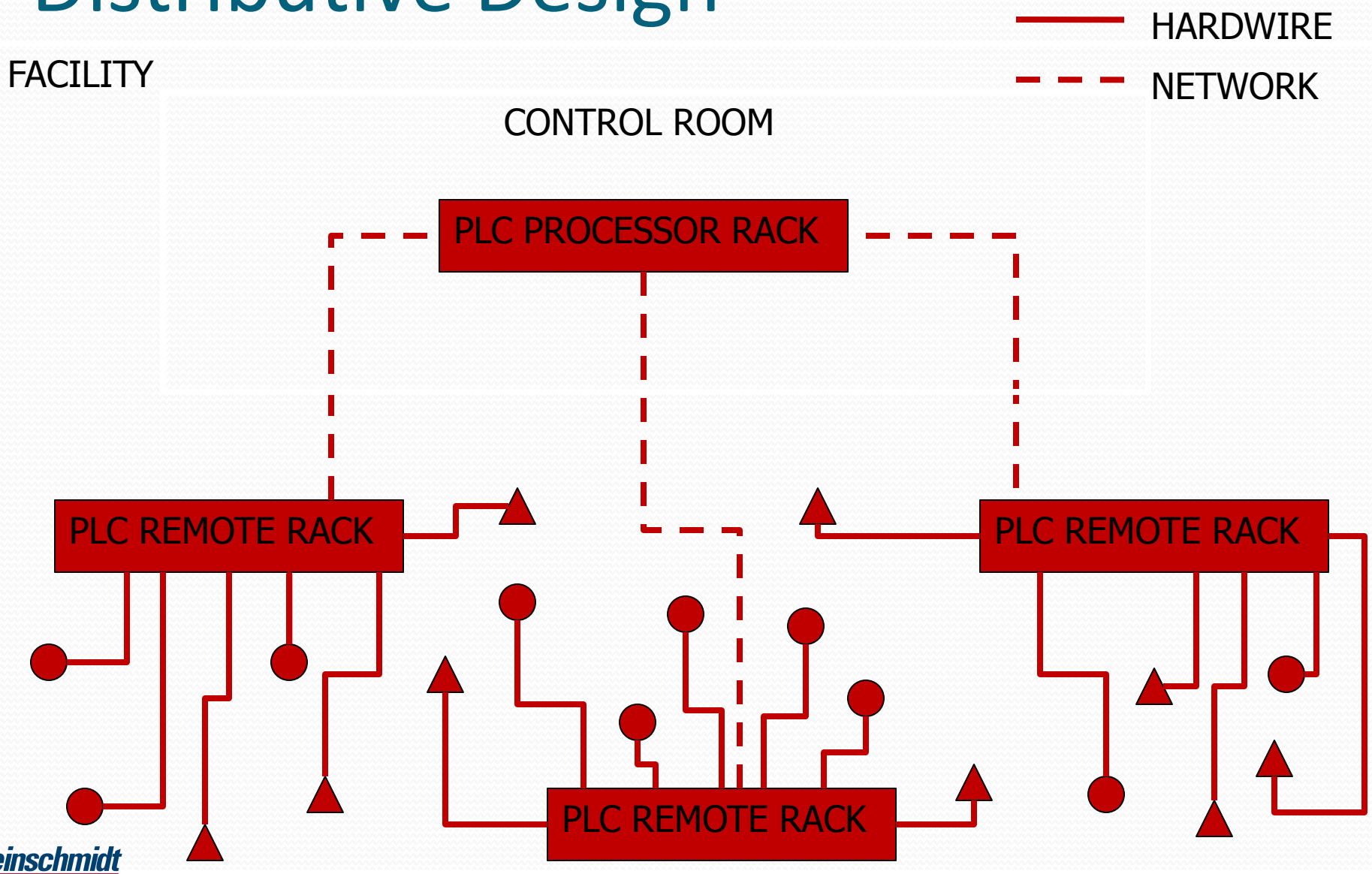
Distributive Design



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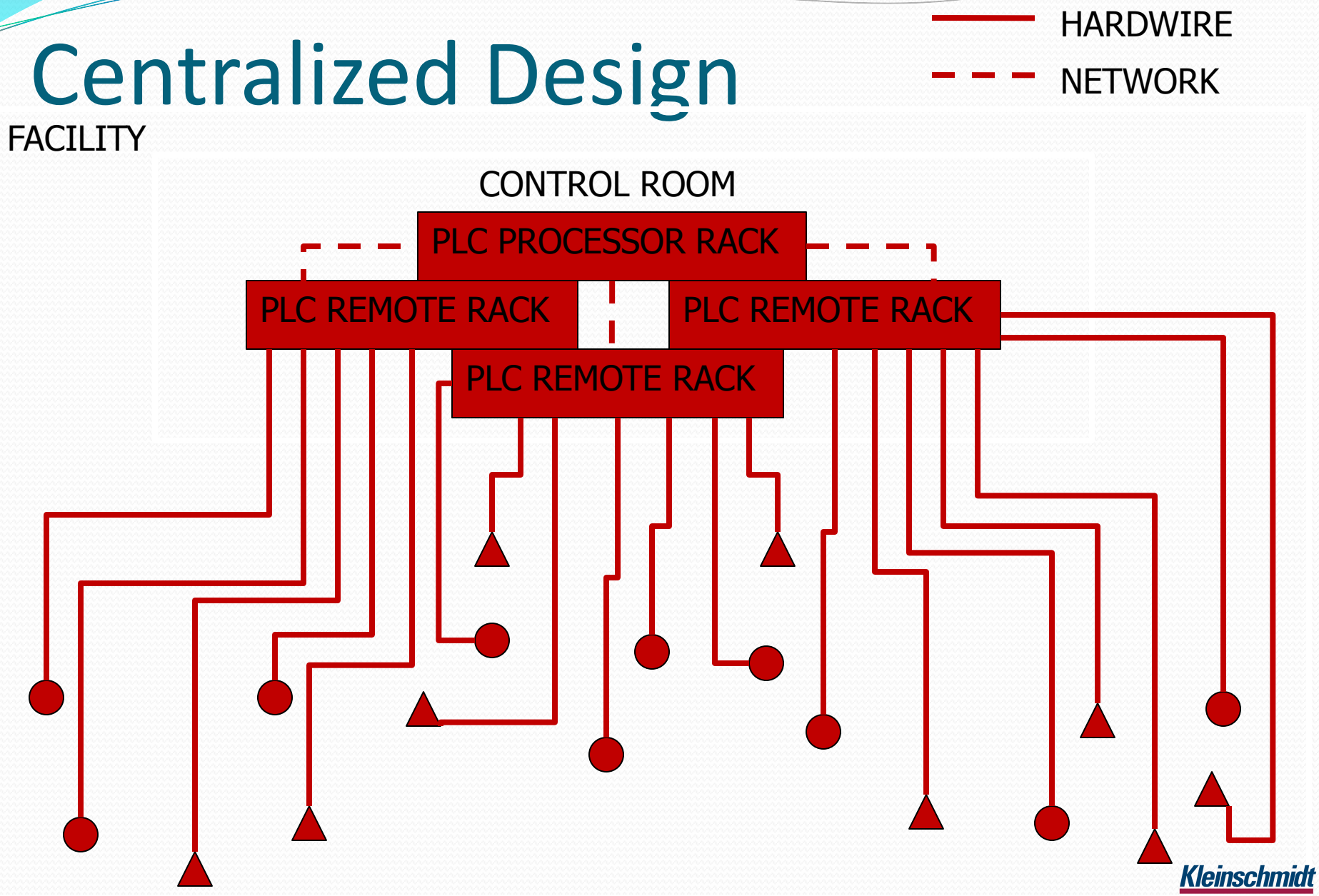
Centralized Design



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Design Approaches

SYSTEM	INSTALLATION COST	SECURITY	MAINTENANCE	TROUBLESHOOTING
Distributive	Medium	Low	Harder (Distributed over large area)	Easier (connection are local to devices)
Centralized	High	High	Easier (Local connections and controls equipment)	Harder (connections are not local to devices)

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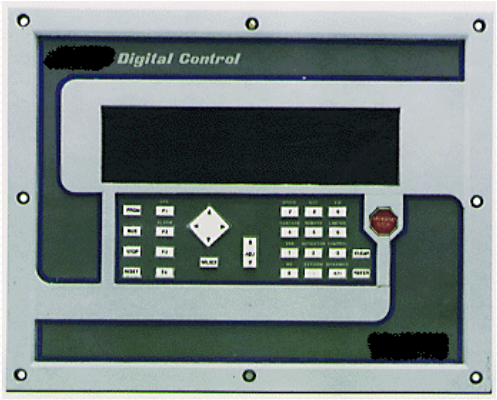
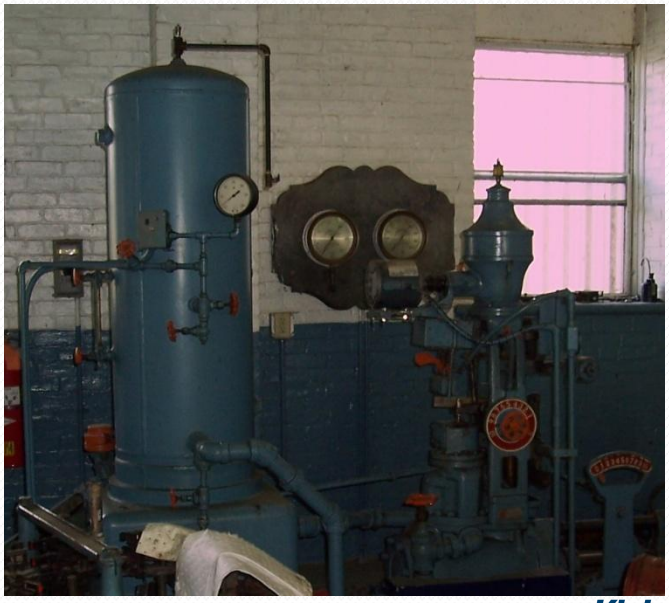
Governor Controls

- Fly Ball
- Digital Governor
- Gate Positioner (PLC)





Governor Controls

SYSTEM	INSTALLATION COST	RESPONSE TIME	ISOCHRONOUS CONTROL
Fly Ball	N/A	Medium	Medium
Digital Governor	High	High	High
Gate Positioner	Medium	Medium	Medium

Small Hydro with Legacy Fly Ball governors often benefit from a retrofit to a Gate Positioner. New Small Hydro often benefits from a Gate Positioner, unless Isochronous Control is very important and dynamic in which a Digital Governor should be used.

Redundancy

- Power Supply Redundancy
- PLC Redundancy (option A): Redundant I/O cards (in a single rack), processors (in a single rack), and power supplies.
- PLC Redundancy (option B): Redundant I/O racks, processor racks, and power supplies.
- PLC Redundancy (option C): Redundant I/O racks, processor racks, networking equipment, networking cables, and power supplies.
- Full Redundancy

- Small Hydro often benefits most from Power Supply Redundancy only.

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Security Issues

- Physical Security
  - Physical security of a previously occupied station (e.g., remote cameras, access controls)
  - Locked six-walled enclosure for networking equipment, with access controls
- Cyber Security
  - Use of firewalls, threat managers, etc.
  - Choice of network protocols
  - Choice of media
  - Hardening of PCs, servers, switches, routers, etc.
- NERC-CIP provides rules, regulations, and guidance

- Small Hydro can often be classified as non-critical assets and can there keep the security requirements low. If the station is classified as a black start asset and used for bootstrapping the grid, however, it may be classified higher requirements more strict security.

Training Considerations

- Modern automation system are fundamentally different from legacy hardwired systems and require a different set of skills to maintain
  - Computer savvy
  - Program applications knowledge
  - Networking knowledge
  - Understanding of I/O hardware and configurations

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Training Considerations

- Operating modern automations, via and HMI, is also fundamentally different and requires additional training
  - Computer savvy
  - HMI menus, paging, and graphics
  - Trending capabilities and configurations
  - Alarm classes and alarm management
- How legacy systems and automation systems interact (in hybrid systems)

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Summary

- Each stakeholder—owners, engineers, operators, and maintenance staff—should be fully engaged during all stages of the design, construction, and start-up process of a hydro unit or hydro station automation upgrade.
- Discussion between all stakeholders should included Design Concepts, Design Approaches, Implementation Strategies, Security Issues, and Training Considerations

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