Clearway Energy

ENERGY CENTER MINNEAPOLIS CONTROL SYSTEM UPGRADE

Control System Upgrade at Energy Center Minneapolis

- System Historical Overview
- Project Drivers
- Project Options Considered
- Selected Project Scope
- Project Schedule
- Project Implementation
- Project Cost
- New System Key Facts
- Lessons Learned
- Questions

System Overview

- Steam, Hot Water and Chilled water district energy system
- Commenced Operations in 1972
- Serves the downtown business core in Minneapolis MN plus two remote plants
- Three steam plants, one hot water plant, six chilled water plants
- 10 Boilers, 17 chillers
- Purchased steam from two Hennepin County plants
- Electric, steam turbine, and gas engine drive chillers
- Natural gas/#2 Fuel Oil boilers
- 660,000 lb/hr peak steam demand
- 30,000 Ton peak cooling demand

System Historical Overview - DCS

- Bailey Infi90 DCS System Installed in 1980's
  - System installed in five plants
  - One plant connected via coax, two DSL, one stand alone
  - Redundant Controllers and HMI's, Non-Redundant I/O
  - Multiple Controller and HMI Upgrades made over time.
- Allen Bradley PLC Systems Installed in mid 1990's
  - Systems installed in two plants
  - Same family but different age/version controllers
  - Connected via Fiber
  - Non-redundant controllers and HMI's, Non-Redundant I/O
  - No controller and HMI upgrades made over time.
  - Primarily used for HVAC, support systems and as communications interface to local vendor controls

Overview – System Map

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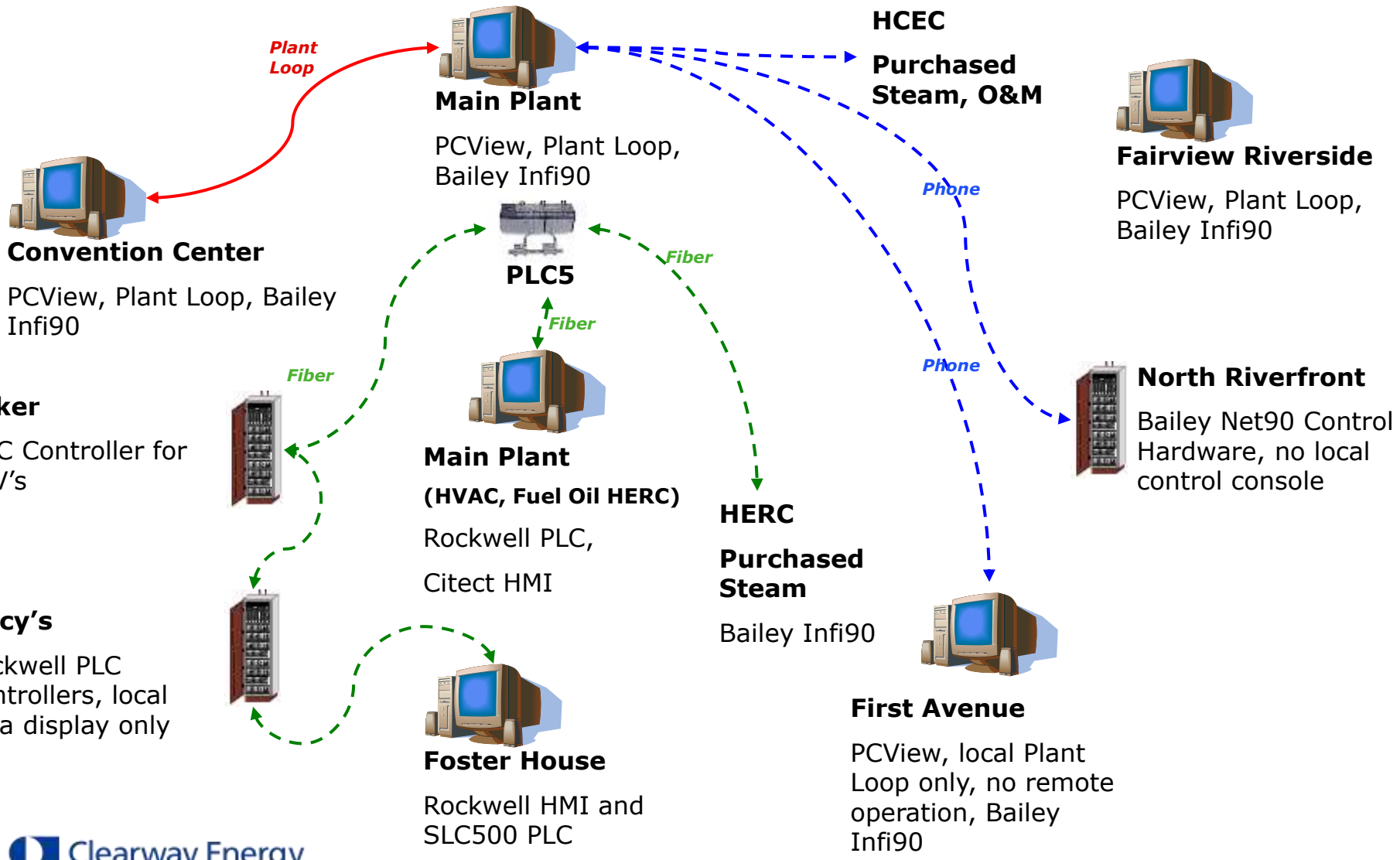
Overview – Current Configuration



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Project Drivers

- 1980's vintage Core DCS system that had been periodically upgraded was reaching true economic end of hardware and software life.
- Software and equipment maintenance costs increasing
- Loss of experienced technical support personnel
- HMI servers reaching end of life
- Multiple systems/vendors that need to communicate

- Level of investment required to bring current system up to date significant enough to justify evaluating complete or partial replacement with alternate vendors
- Access advanced control, monitoring, diagnostic, and record keeping capabilities of newer DCS systems

Main Project Options Considered – Core DCS System

1. Upgrade/Replace Controllers, Power Supplies and HMI's with current manufacturers most current compatible products. (keep I/O and backplane)
2. Upgrade/Replace Controllers, Power Supplies and HMI's with alternate manufacturers compatible products. (keep I/O and backplane)
3. Upgrade/Replace Controllers, I/O, Power Supplies and HMI's with current manufacturers most current compatible products (keep I/O Backplane)
4. Upgrade/Replace Controllers, I/O, Power Supplies and HMI's with alternate manufacturers compatible products (keep I/O Backplane)
5. Replace Controllers, I/O, Power Supplies and HMI's with current manufacturers most current product.
6. Replace Controllers, I/O, Power Supplies and HMI's with alternate manufacturers most current product newer DCS systems

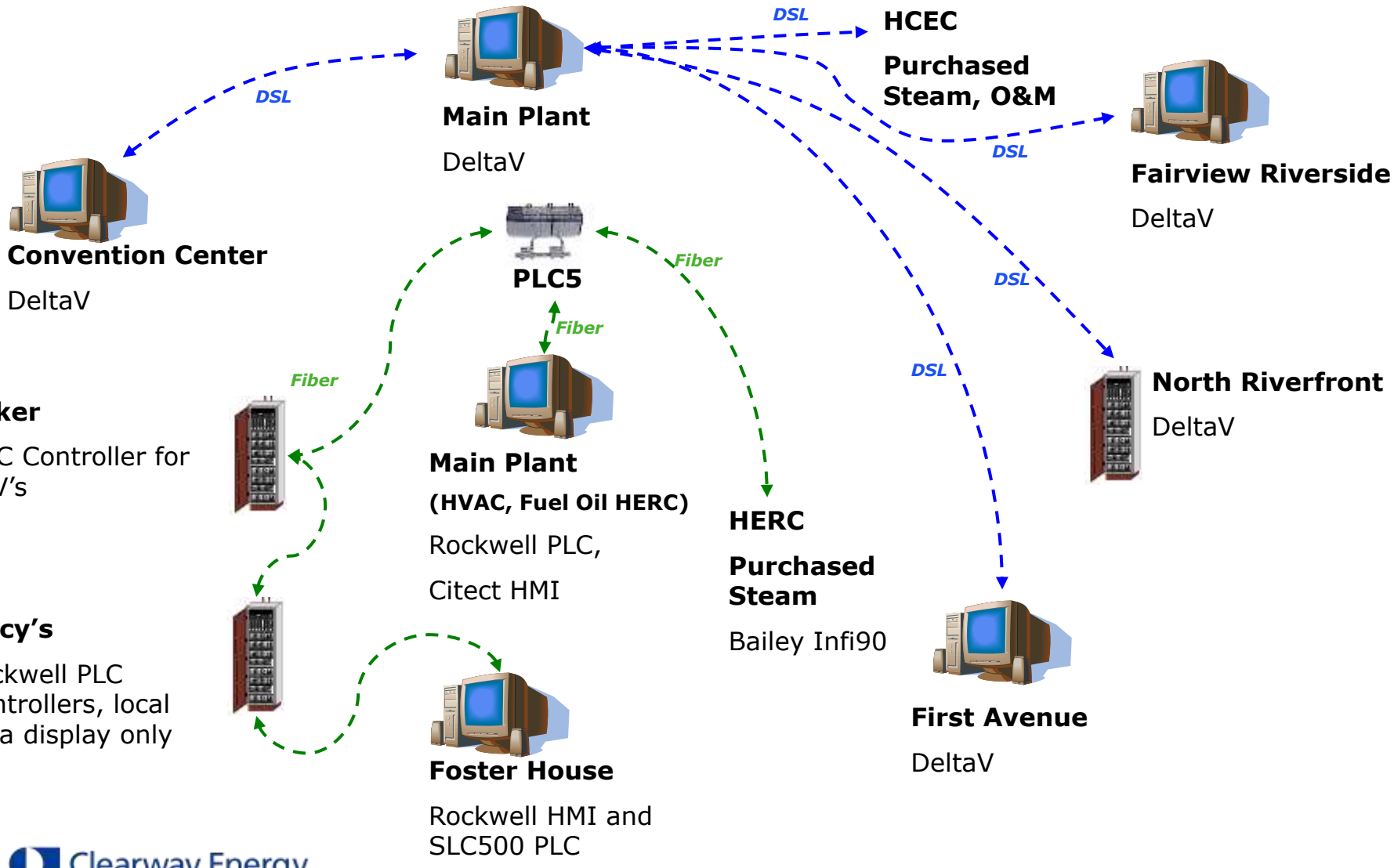
Project Options Considered – Other Components

- Establish Communications with Fairview Riverside Plant
- Replace everything with same as rest of the system or retain existing Allen Bradley PLC Control Systems (Main Plant HVAC & Fuel Oil, Foster House, Macy's)
- Retain existing coax, replace with fiber-optic, or switch to DSL communications for Convention Center Plant
- Install fiber optic or switch to DSL for 1st Avenue Plant
- Include new BMS systems in project scope
- Include instrumentation asset management functionality
- Replace all or portion of instrument wiring.

Selected Configuration

- Replace Controllers, I/O, Power Supplies and HMI's with current or alternate manufacturers most current product for North Riverfront, 1st Ave, Convention Center and Main Plant (Existing Bailey Infi90 systems)
  - Emerson Delta V was selected.
- Retain existing Allen Bradley control systems at Macy's and Foster House Plants.
- Retain existing Fisher ROC/Single Loop Controller control system at Baker Plant
- Retain existing fiber optic communications with Baker, Macy's and Foster House
- Switch to DSL communications for 1st Ave, Convention Center and Fairview Plants
- Upgrade fiber optics communications interfaces at all connected plants
- Replaced all I/O wiring back to local equipment control panels and majority of standalone instruments

Overview – Selected Configuration



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Project Implementation – Schedule

- Initial discussions started in 2009
- Development of project scope was started and stopped multiple times over the next 6 years due to budget constraints and lack of consensus on scope.
- October of 2014 consultant hired to develop project scope
- Proposals solicited fall of 2015
- DCS vendor awarded February of 2016
- System configuration, cabinet construction and FAT complete September of 2016
- Operator training completed in August of 2016
- Phase I - NRP and Main Plant HMI's installation started September of 2016
- Phase II – 1st Avenue, Convention Center and Foster House plants installation started November of 2016
- Phase III – Main plant installation started March of 2017.
- Phase IV installation – Fairview Riverside started June of 2017
- Project complete December 2017

Project Implementation – Key Aspects

- Utilize 3rd Party Consultant to Help Evaluate Current and Future Needs and Support Project Development and Construction
  - Conduct stakeholder meeting
  - Evaluate Potential Vendors
  - Prepare Project Requirements Document and Procurement Specification
  - Provide Technical Support for Design, Installation and Commissioning
  - Develop Project Implementation Plan

- Comprehensive Bid Evaluation Matrix/Scoring
  - Equipment Cost
  - Configuration Cost
  - Schedule
  - Functionality
  - Life Cycle
  - Support Capabilities
  - Support Cost
  - Training Cost

Project Implementation – Key Aspects

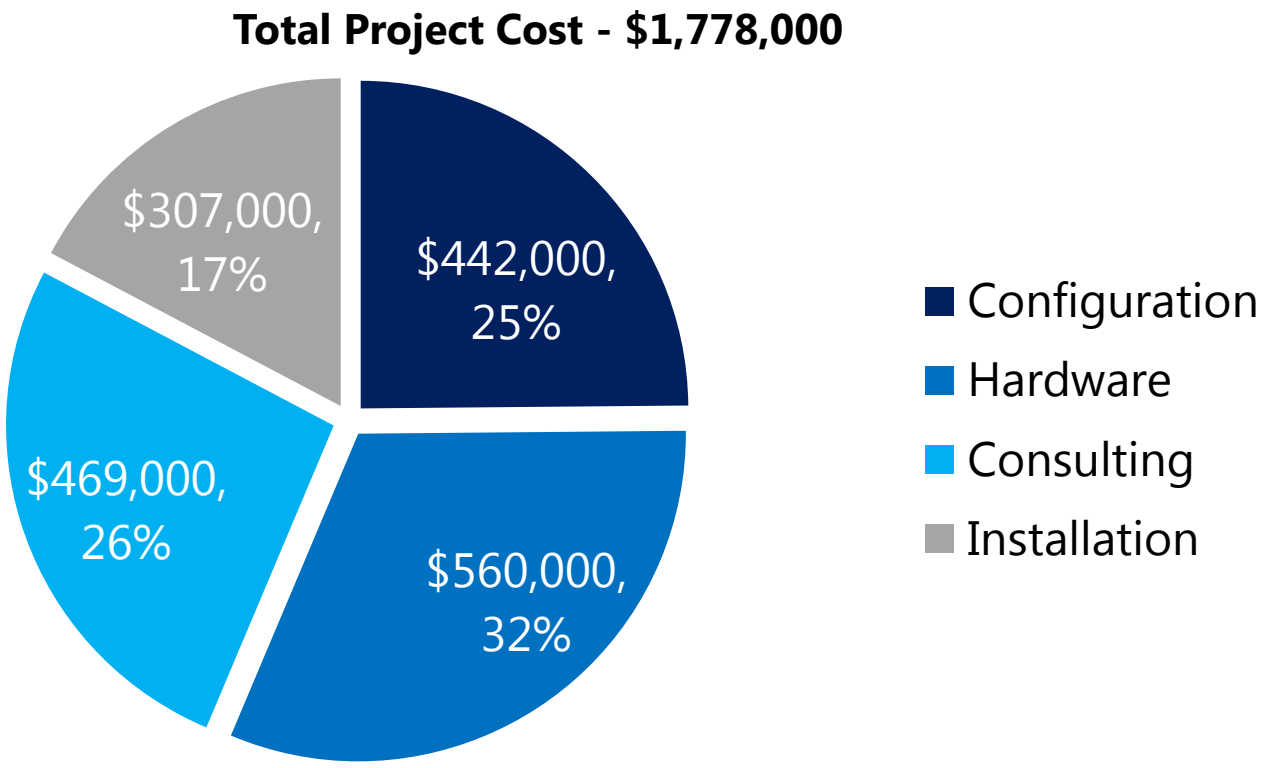
- Stakeholder meetings to finalize project scope and create buy-in
- Award, Develop and Approve Final Hardware and Configuration Scope Prior to Developing Installation Bid Documents
- Utilize phased approach to installation and commissioning
  - Avoid overburdening plant operators and I&C staff
  - Identify unknown/missed items so they can be corrected before the next phase.
- Complete comprehensive Operator training using simulator with actual configuration
- Fully document existing system components and wiring to remain.

Project Implementation Plan Elements

- Stakeholder meetings to final and achieve consensus on project scope
- Prepare project hardware and configuration procurement specifications
- Hardware and configuration bid solicitation, review and selection
- Hardware and configuration submittal review and acceptance
- Prepare project installation specifications
- Installation bid solicitation, review and selection
- Comprehensive off-site Operating training
- Comprehensive Factory Acceptance Testing
- Phased implementation approach
- Complete installation, commissioning and operational break-in period for each phase before commencing next phase
- Small independent North River Front Plant first
- 1st Ave Satellite , and Convention Center Plants next
- Main Plant and Fairview Riverside last

Project Cost

Project Cost Breakdown



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System Size

Hardware	Qty
Redundant Pairs Controllers	6
Analog I/O Modules	67
Discrete I/O Modules	66
Redundant Pairs Power Supplies	6
Quad Screen Operator Workstations	2
Dual Screen Operation Workstations	4
Engineering/DAQ Workstations	2

Graphics	Qty
Process Overview	5
Process System	20
Process Unit	22

I/O	Qty
Analog I/O	617
Discrete I/O	397
Pseudo Analog I/O	90
Pseudo Discrete I/O	28

Control Points	Qty
Analog Indicators	351
Digital Indicators	247
Analog Control Loops	131
Discrete Control Modules	87
Custom Control Modules	13

Project Lessons Learned – What We Did Right

- Utilize knowledgeable 3rd party consultant to guide all phases of the project
- Develop, award and approve final hardware and configuration design prior to developing installation bid documents
- Complete comprehensive off-site operator training in advance of initial implementation
- Utilize phased approach to prevent overburdening operations personnel and to identify unknown/missed items to be corrected before next phase
- Involve as many plant operations personnel as possible in system commissioning.
- Accurately document and label existing I/O and wiring and terminations

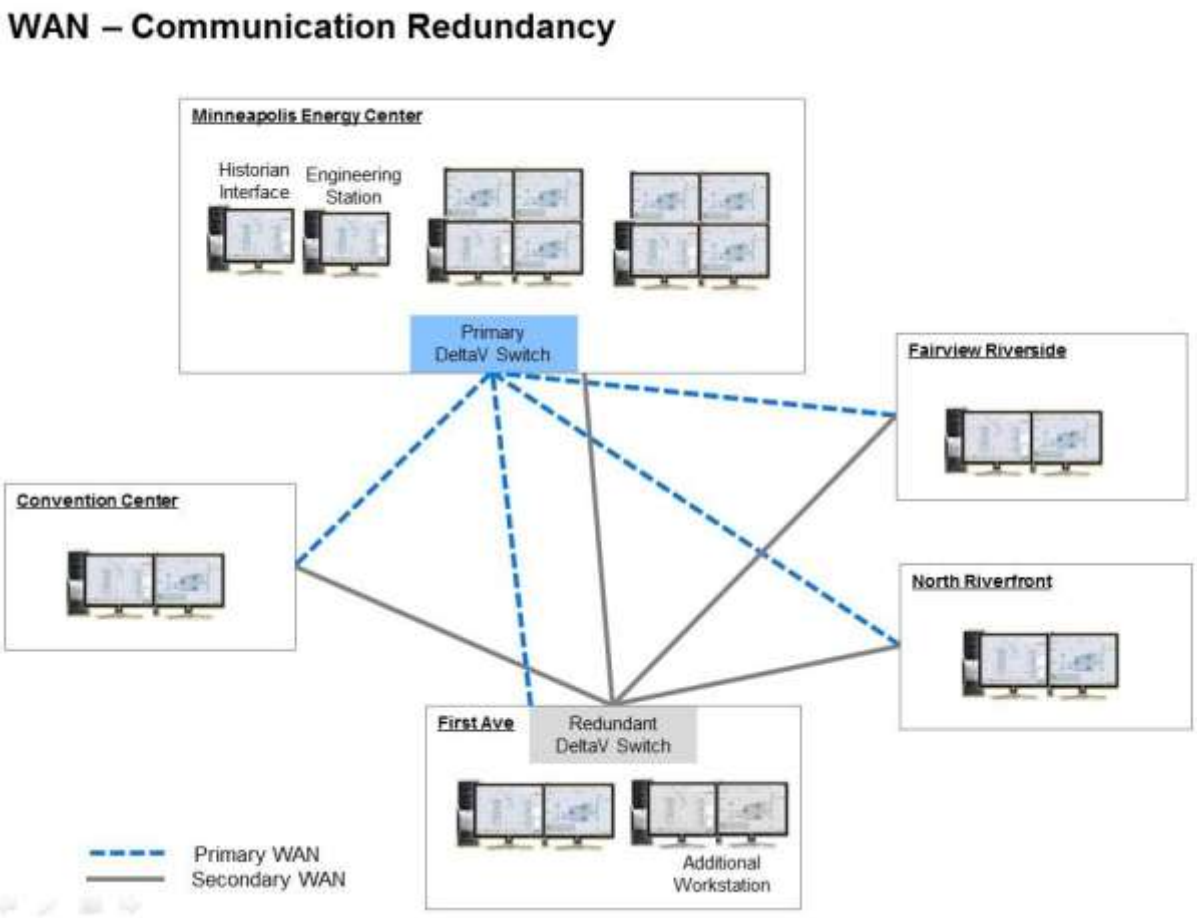
Lessons Learned – What We Did Wrong

- Assign project manager (preferably 3rd party) to take the lead on developing initial draft scope vs trying to develop scope by committee.
- Start with one on one interviews with various stakeholders
- Don't overload stakeholders with too much information – break scope into distinct smaller categories and reach consensus in steps.
- Start discussions with 3rd party communication vendors as soon as possible and leave sufficient time in schedule to secure service

Thank You

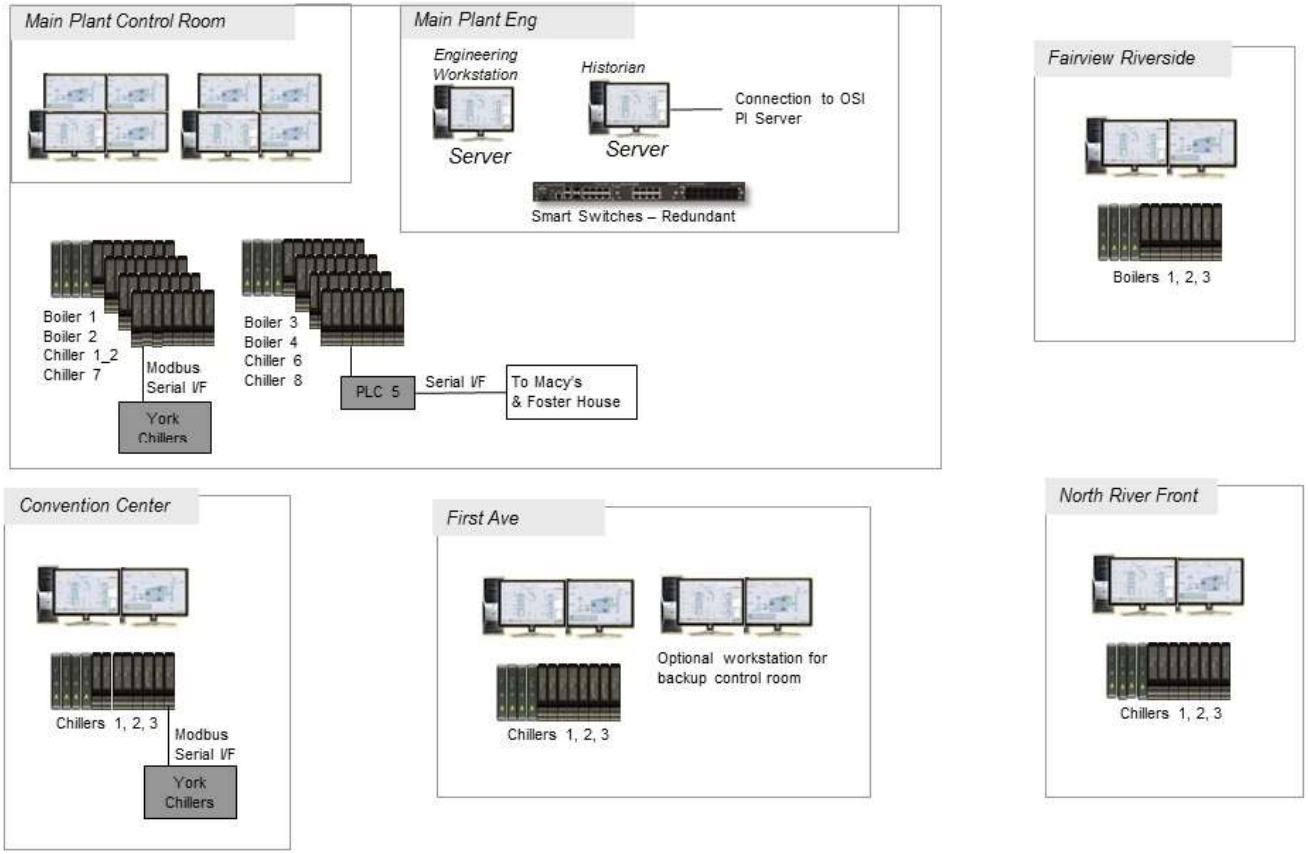
Questions?

Project Network Configuration



Project Network Configuration

DeltaV Architecture Diagram – Final Phase of Phased Implementation



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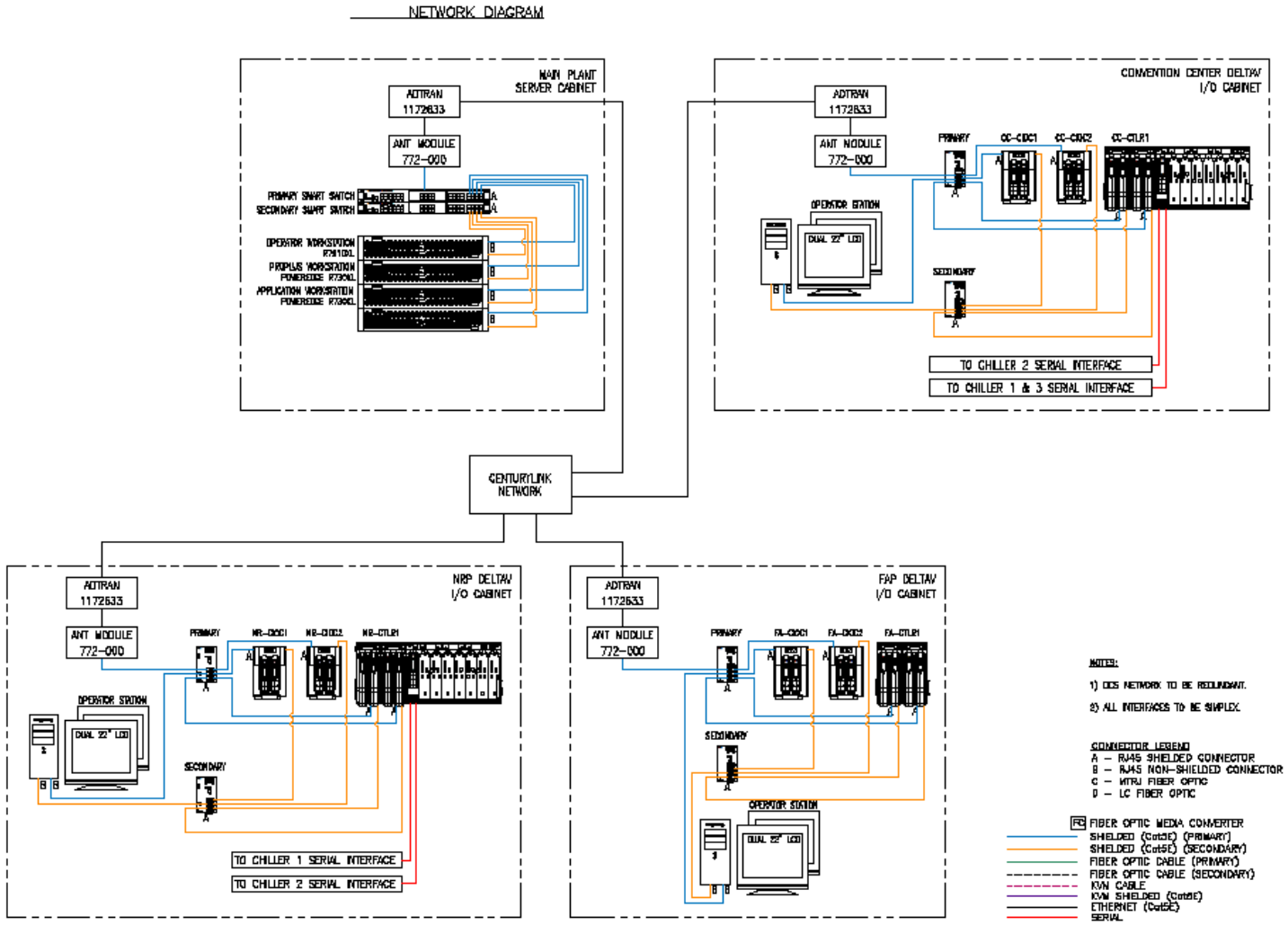

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Installation Pictures

EXISTING SYSTEM

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Installation Pictures

NEW SYSTEM

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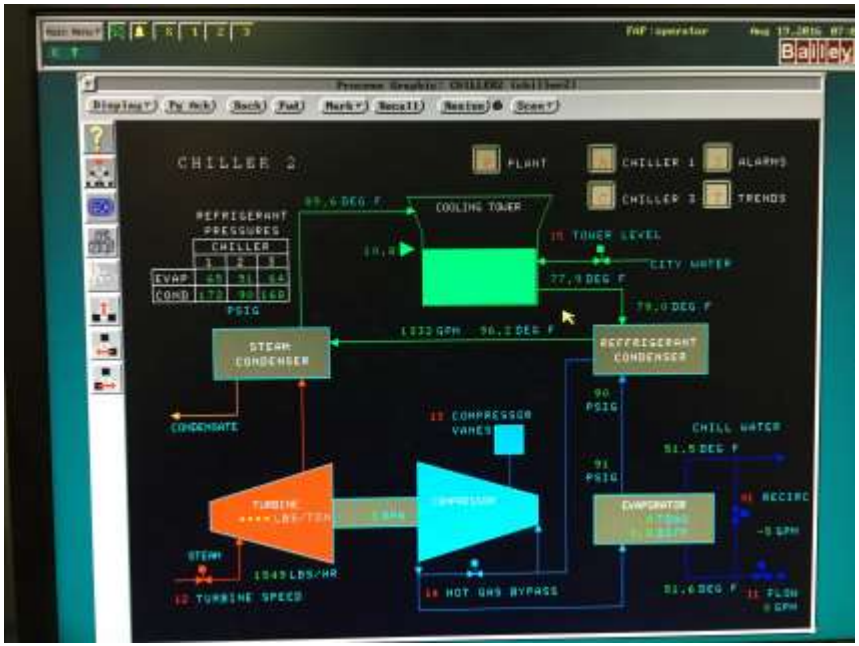
Installation Pictures

EXISTING SYSTEM GRAPHICS



NEW SYSTEM GRAPHICS

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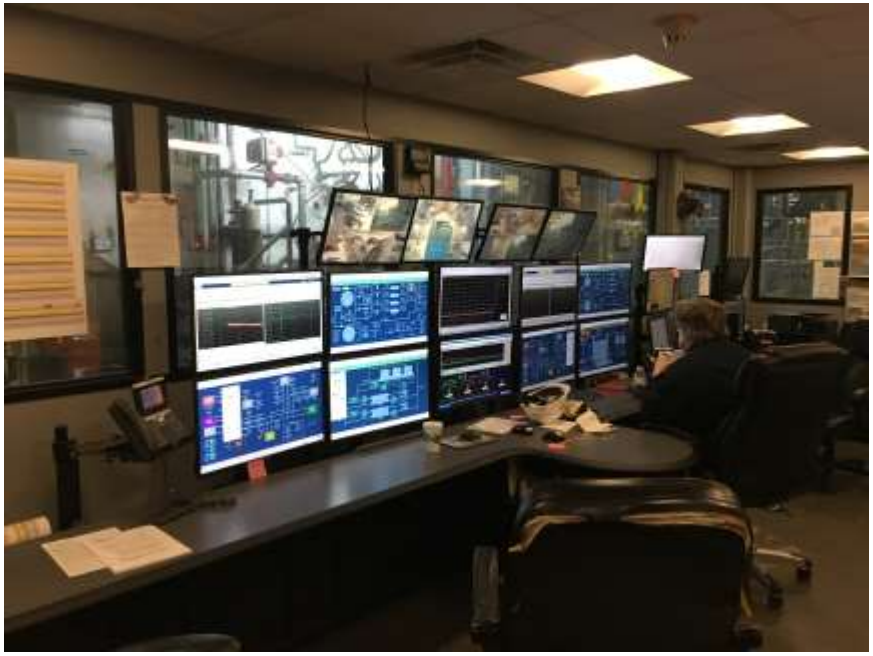
Installation Pictures

EXISTING SYSTEM

NEW SYSTEM



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