Clearway Energy

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

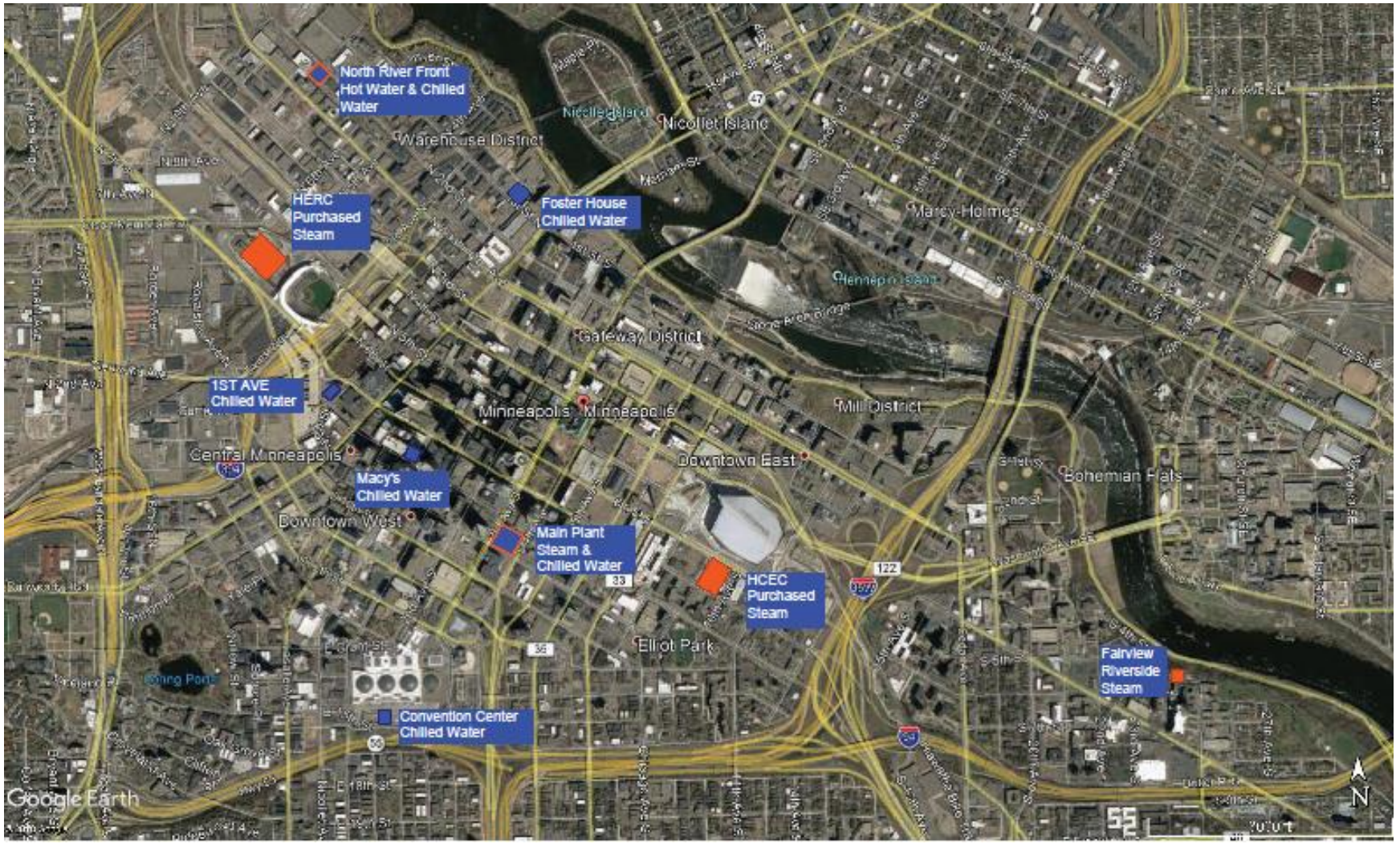
System Overview

- 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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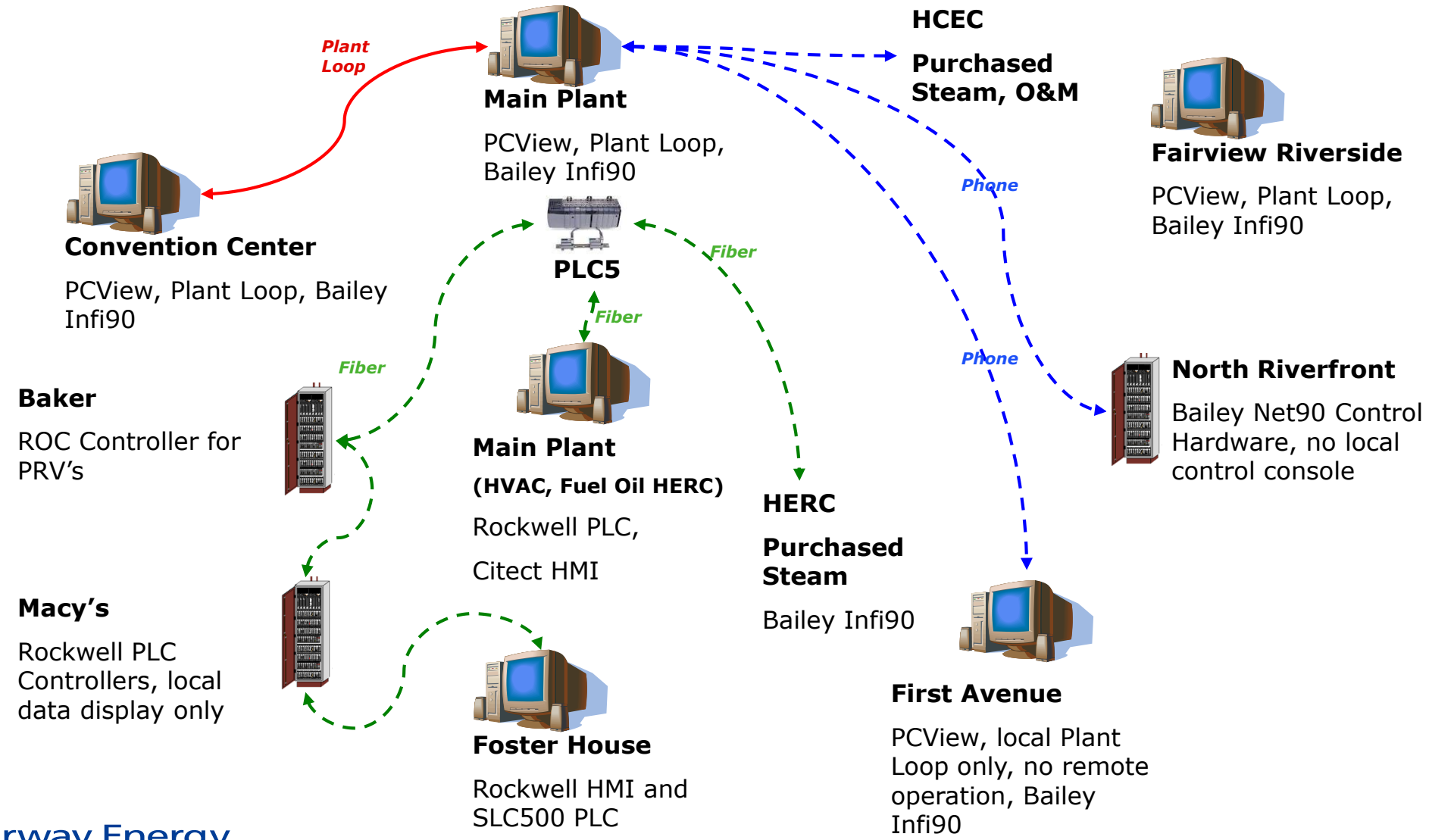
Overview – Current Configuration



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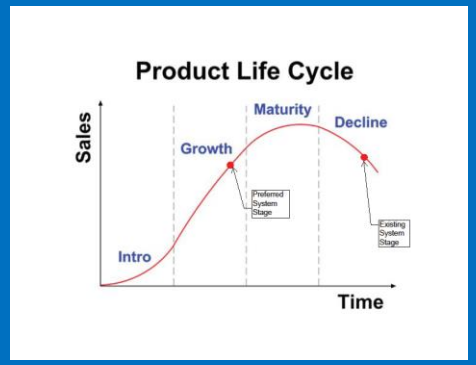
Project Drivers

- 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

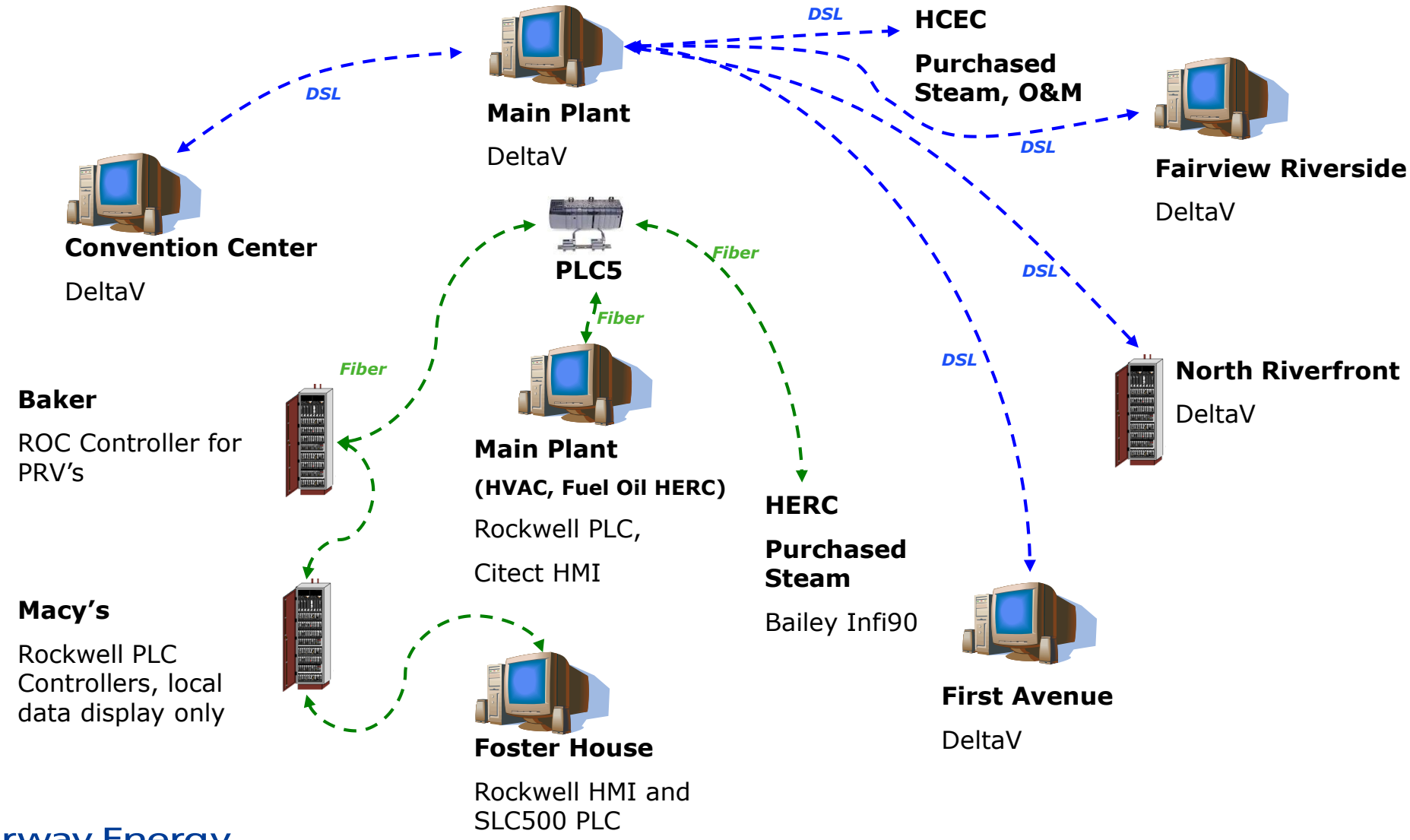
Project Options Considered – Other Components

- 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

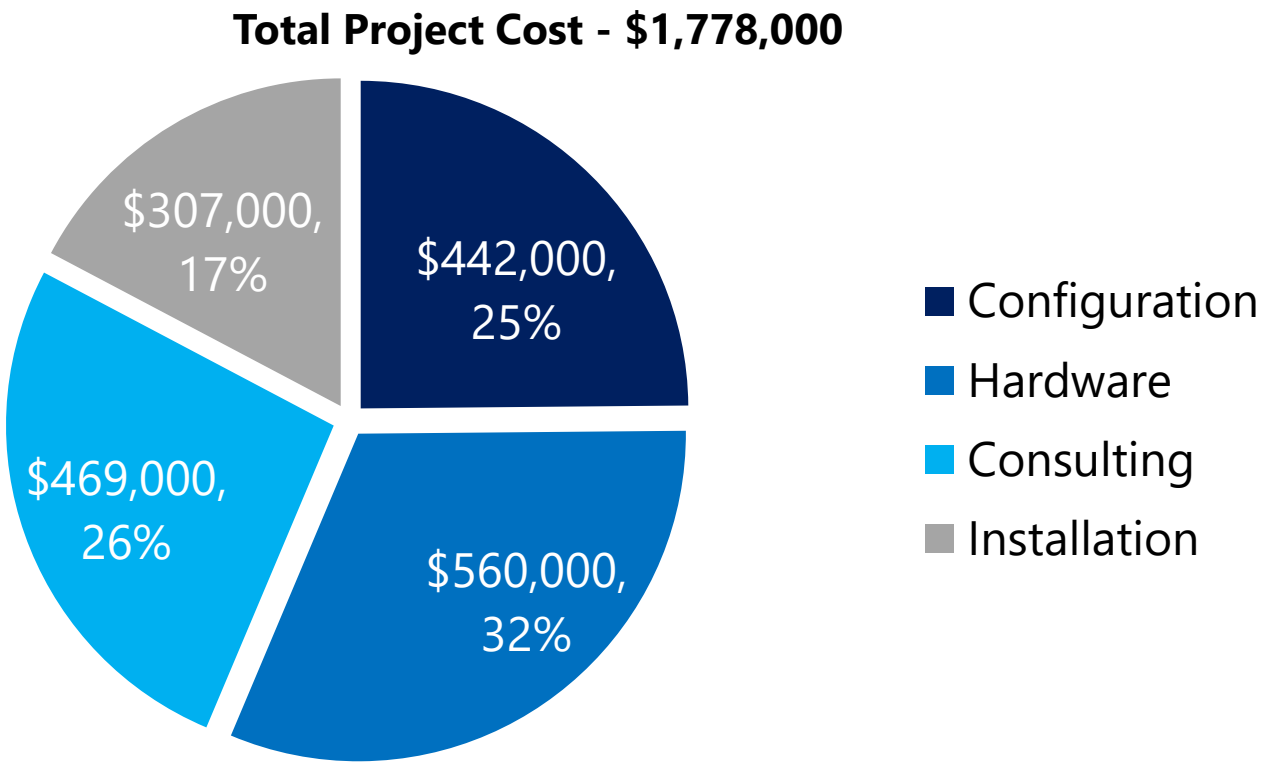
- Stakeholder meetings to finalize project scope and create buy-in
- Award, Develop and Approve Final Hardware and Configuration Scope Prior to Developing Installation Bid Documents
- Utilize phased approach to installation and commissioning
  - Avoid overburdening plant operators and I&C staff
  - Identify 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?

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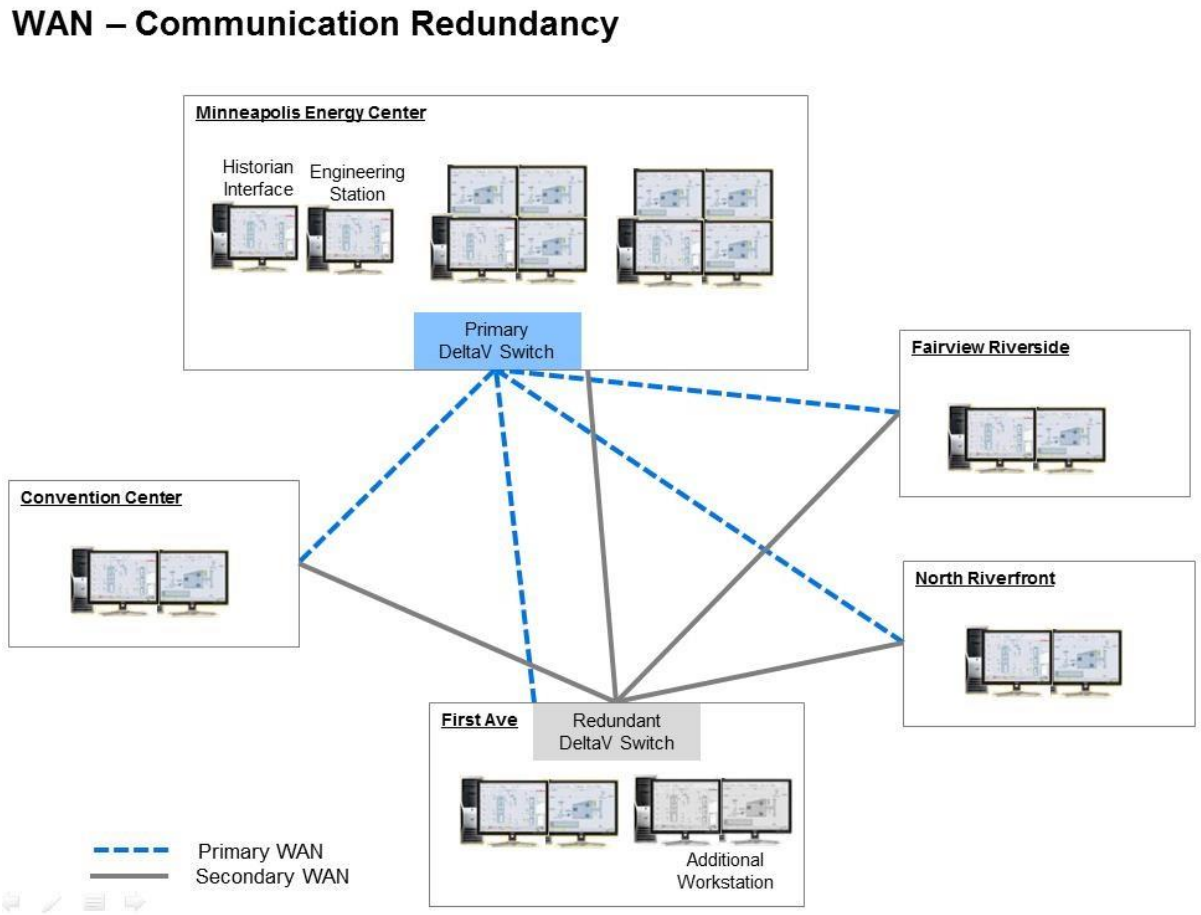
Project Network Configuration



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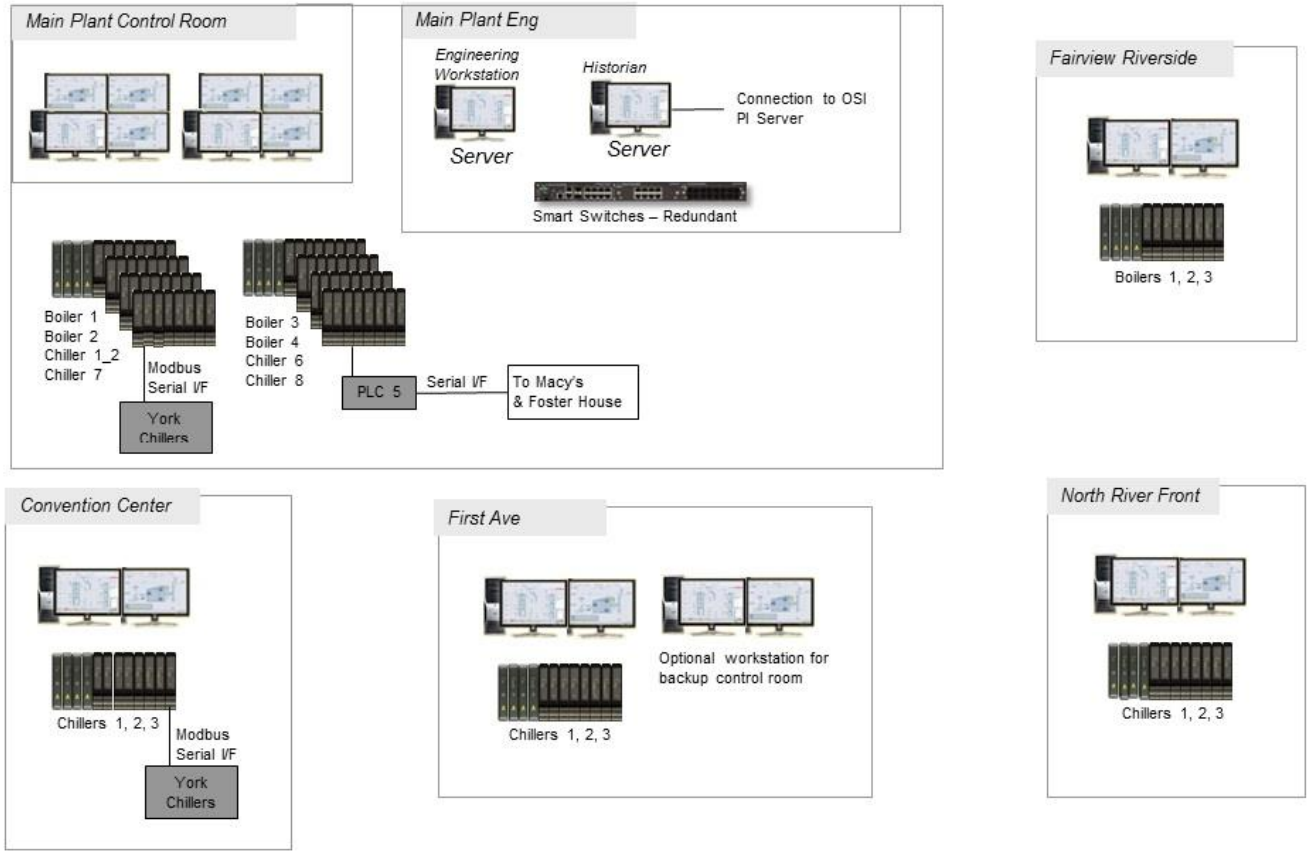
Project Network Configuration

DeltaV Architecture Diagram – Final Phase of Phased Implementation



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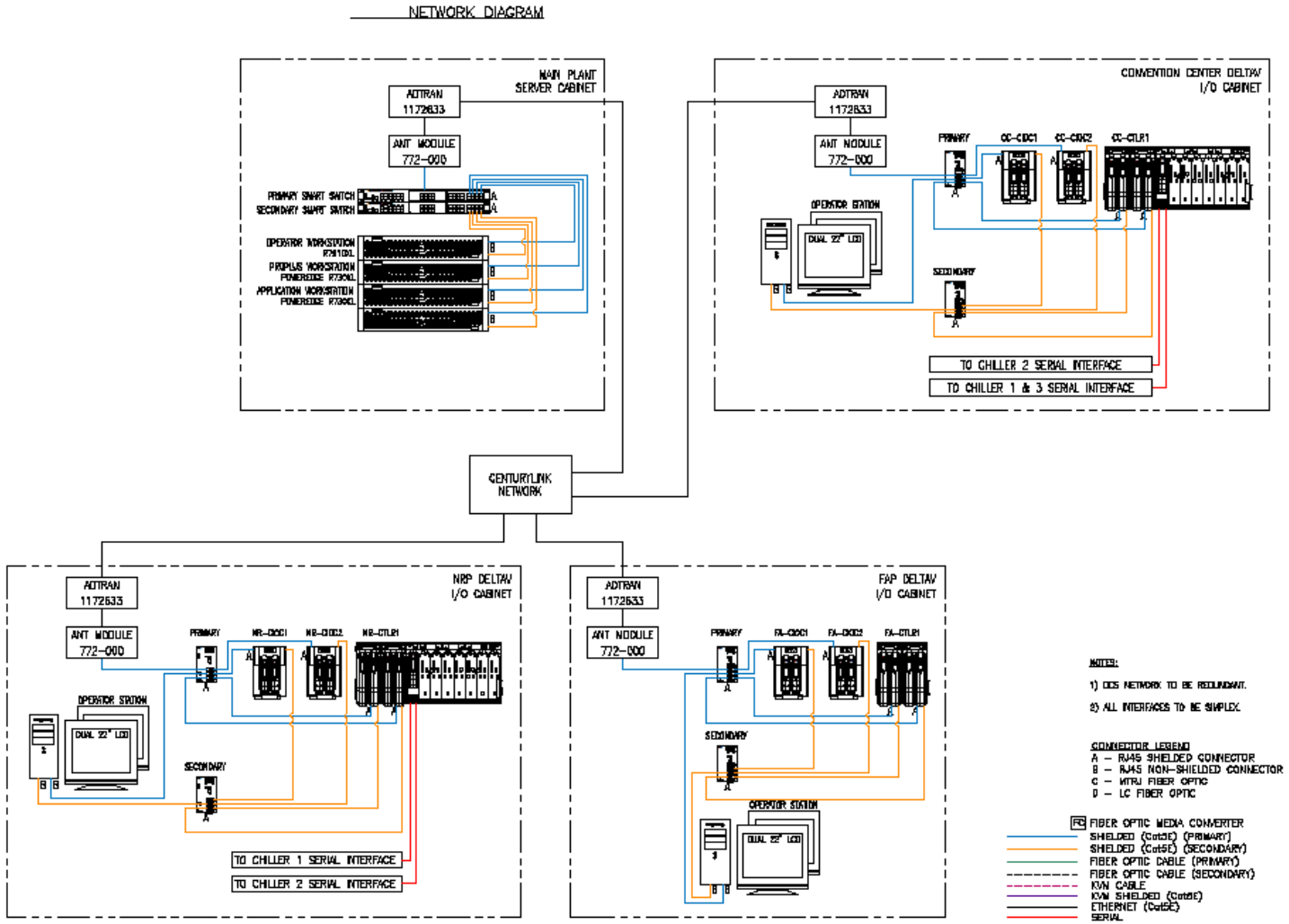

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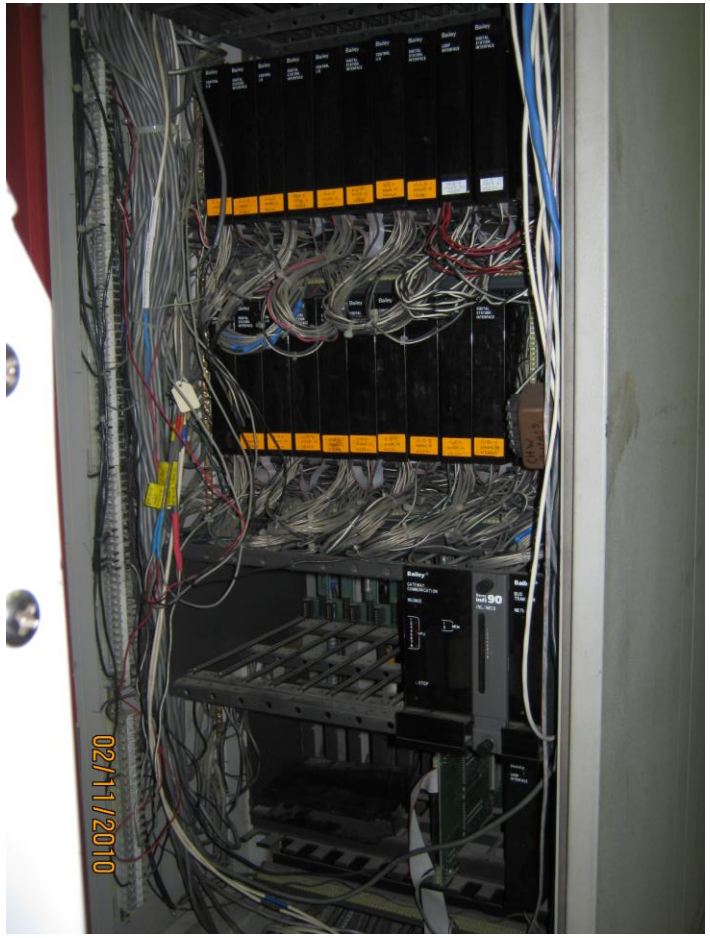
Installation Pictures

EXISTING SYSTEM



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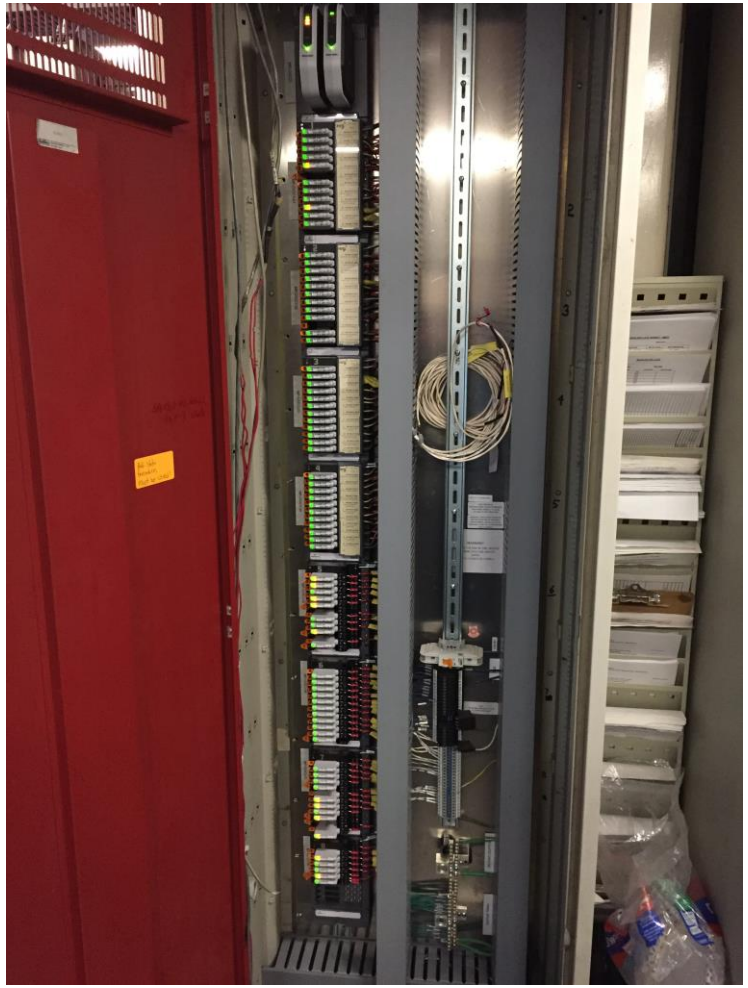
Installation Pictures

NEW SYSTEM



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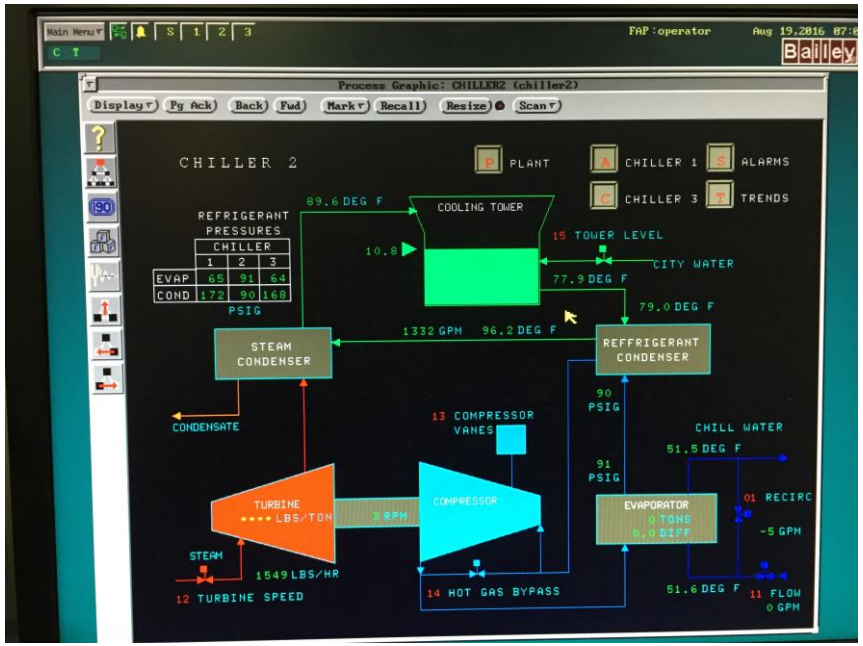
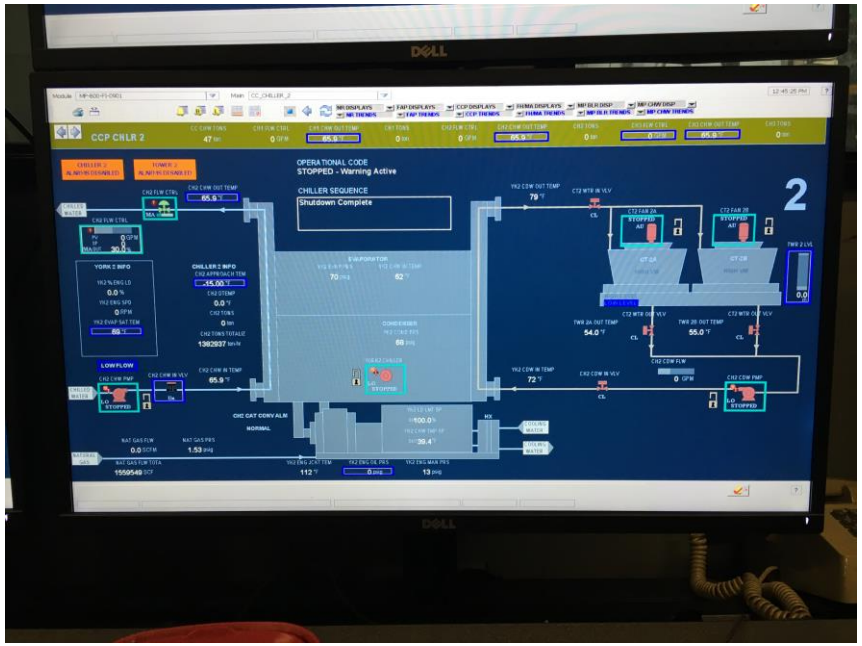
Installation Pictures

EXISTING SYSTEM GRAPHICS



NEW SYSTEM GRAPHICS



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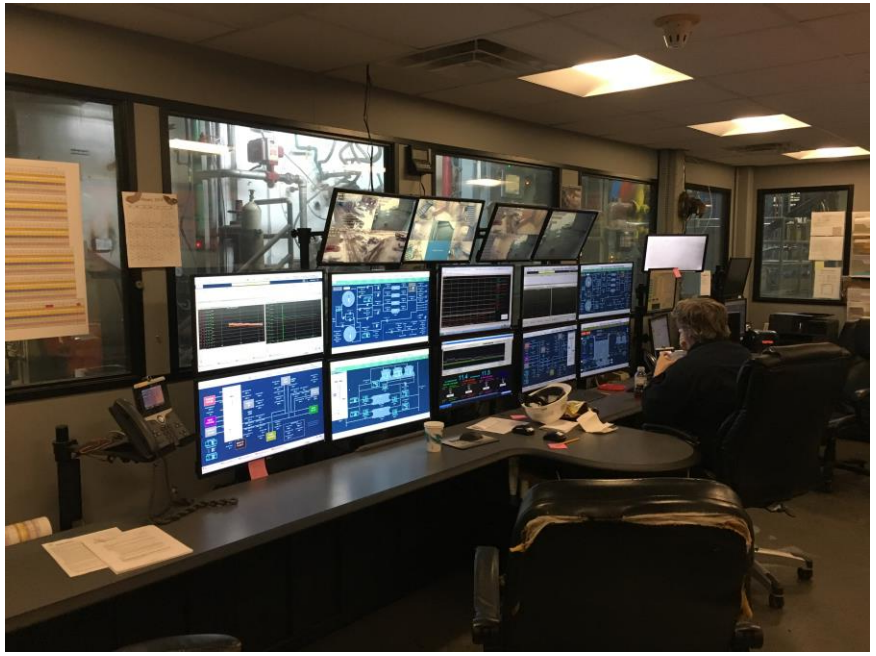
Installation Pictures

EXISTING SYSTEM

NEW SYSTEM



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