Canadian Consulting Engineering Awards 2016

SCADA Data Centre Refurbishment and Upgrade

Project Binder

Category: Technical Buildings Category

Edmonton, AB

April 2016
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1. Project Description

EPCOR is in the process of renovating and expanding its North Service Centre Facility in Edmonton, Alberta. This facility is used by EPCOR to house its field services, equipment yard, and SCADA Control Centre. The upgrade will include new architectural, mechanical and electrical retrofits.

As part of the renovation EPCOR’s SCADA team is upgrading the North Service Centre (NSC) SCADA data centre room. The NSC SCADA room is a Mission Critical Facility (MCF) which monitors and controls EPCOR’s electrical distribution assets. These assets are very important as they serve more than one million customers within and around the greater Edmonton area.

A significant part of the legacy SCADA system’s operational status will be maintained until the new equipment is commissioned and tested.

The SCADA system upgrades include the installation of multiple blade servers and storage arrays, which require a concurrently maintainable and redundant supporting infrastructure, including a power distribution system, cooling system and ancillary systems (control and monitoring, access control, life and safety systems).

The net value of the new IT components has been determined to be $2M and the CAPEX of the new supporting infrastructure is valued at $1.9M.

1.1 CIMA+ Scope of Work

EPCOR assigned the work of engineering the SCADA system upgrades to the Mission Critical Facility team of CIMA+. CIMA+ was tasked with identifying and designing all required upgrades of the supporting infrastructure. This work and tasks included:

+ Interacting with the EPCOR SCADA team to evaluate all project requirements and validating all design concepts on a technical and practical (constructability) point of view;
+ Confirming the required cooling capacity and the required power distribution system capacity, as well as all required upgrades (power cooling, life and safety);
+ Re-configuring the layout of the computer room;
+ Determining and establishing a phasing program for the installation of all required racks, cooling system, and IT systems (blade servers, storage array, switches) while maintaining operational continuity of the existing system.

1.2 New or Advanced Approach

1.2.1 Key System Procurement

The project execution was based on an accelerated pre-purchase procurement strategy founded on the need to have available all of the equipment for the new systems. No customized solutions were retained to alleviate issues related to long lead items.

1.2.2 Life and Safety

A multi stage fire detection and suppression system was installed to provide protection against fire for both site personnel and for the SCADA system.

The SCADA computer room has been equipped with an advanced warning system based on VESDA’s air sampling system, smoke and heat detector. A multi stage fire suppression system inclusive of a clear gaseous agent system and pre action sprinkler was installed.
1.2.3 Room Topology

The original floor plan of the SCADA room as shown in Figure 1 was maintained:

+ Space was allocated for the installation of temporary equipment to allow the EPCOR SCADA team to proceed to the testing and commissioning of its new SCADA systems (Figure 2);
+ The computer room was refurbished to use a state of the art (Figure 2) energy efficient cooling system based on “in row” solutions comprised of computer Racks, Computer Room Cooling Unit (CRAC), Power Distribution Units (PDU) and a hot aisle containment system (Figure 3).

![Figure 1 – Original SCADA Data Room](image1)

![Figure 2 – In Row System with Air Containment (Hot Aisle)](image2)

![Figure 3 – SCADA Data Room/Layout Overview](image3)
The construction was scheduled into four phases:

- **Phase 1:** Owner procurement of critical and long lead time equipment and the installation of temporary racks and portable cooling systems;
- **Phase 2:**
  - CRAC unit 1, 2 and 3 were installed within the new Row No. 1. CRAC unit, and 4 and 5 were installed in Row No. 2. This will provide 12.5 tons of cooling and allow for the complete dismantlement and removal of the existing CRAH and CRAC units and associated piping and duct work;
  - A temporary containment kit was installed to accommodate the difference in cabinet elevation between the Row No. 1 new cabinets and the remaining cabinets;
  - 100 per cent of all CRAC units piping and electrical wiring was installed for all 8 units. The piping will be equipped with shut off valves and compression connections at both ends to facilitate equipment installation, maintenance and replacement.
- **Phase 3:** The remaining 50 per cent of Row No. 1 was replaced complete with CRAC unit No. 6;
- **Phase 4:** Row 2 was replaced complete with CRAC units No. 7 and 8 and the Row 2 hot aisle containment kit.

This approach ensured that both legacy systems and new systems could be operated in parallel for a few months while maintaining appropriate cooling capacity.

### 1.3 PROJECT SCHEDULE

#### 1.3.1 Engineering

CIMA+ was commissioned to prepare an assessment of the existing cooling and power distribution system in September 2014, and was subsequently awarded the engineering contract in October 2014:

- The preliminary engineering and scoping study complete with a Class D cost estimation was completed in a one month timeframe from mid-October 2014 to mid-November 2014;
- The detailed engineering was executed over two months from January 2015 to the end of February 2015.

#### 1.3.2 Construction

The CIMA+ engineering team proposed to divide the construction activities into four phases, as per the following:

- **Phase 1 Preliminary (December 2014):**
  - Procurement of key items (UPS panel, Mechanical Panel and A-MTS);
  - Demolition of dropped ceiling;
  - Installation of sealant for all existing roof and wall penetrations;
  - Installation of temporary racks to allow for the early testing and commissioning of the new SCADA system;
  - Installation of temporary portable cooling units.
Phase 2 (2015 Q2 and Q3):
- Renovation and refurbishment of the SCADA room;
- UPS modifications;
- Installation of 50% of row No. 1;
- Installation of five CRAC units;
- Installation of 100% of the mechanical and power supplies for eight CRAC units;
- Demolition of the existing cooling system;
- Mitigation of multiple code deficiencies with the exception of the clearance between row No. 2 and the south wall.

Phase 3 (2015 Q4 to 2016 Q1):
- Installation of the second half of row No. 1;
- Installation of a CRAC unit.

Phase 4 (2016 Q2):
- Installation of row No. 2;
- Installation of two CRAC units;
- Mitigation of last remaining code deficiencies: Clearance between row No. 2 and the south wall.

Phase 2 construction was completed 90 per cent on time and within budget. The remaining items including the UPS modifications will be installed during Phase 3.

1.4 Original Cost Compared to Final Cost

1.4.1 Design/Engineering Cost
The engineering fees for the preliminary study and the detailed engineering for Phases 2 to 4 was $288,000. No engineering scope changes have occurred.

1.4.2 Total Capital Cost
The capital cost for all phases was estimated at $1,831,823.56 + GST.
- Phase 1: Estimated Cost: $90,000. Actual Cost: $89,300.00;
- Phase 2: Estimated Cost: $944,790.00. Actual Cost: $925,00.00;
- Phase 3: Estimated Cost: $175,852.44. Actual Cost: Contractor pricing: $172,000.00;
- Phase 4: Estimated Cost: $293,605.56. No construction contract has been awarded to date.

1.5 Level of Success
The phasing drawings resulted in a carefully planned construction sequence. A minimum number of contractor issued Request for Information were issued during construction and minor adjustments to adjust to field specific conditions were required. No additional construction costs have been paid by EPCOR to date.

To date the implementation of Phase 1 and Phase 2 has resulted in no operational down time. During this period significant operational improvements were achieved for the power distribution system and the cooling system.
2. Technical Excellence

To ensure seamless project execution, CIMA+ assigned its Mission Critical Facility team to the redesign of EPCOR’s SCADA data centre.

This group includes designers who are trained and certified by industry leading organization’s including CNET, the Uptime Institute and EPI/TIA.

The design and all related innovative solutions were based on best practices published by:

+ The Alberta Building Code;
+ The National Building Code;
+ The Canadian Electrical Code;
+ ASHRAE, Uptime Institute, TIA-942.

3. Degree of Difficulty

The design team faced a number of challenges each of which was met with a resolve to determine a best course of action.

3.1 Existing System

A preliminary assessment of the project by CIMA+ in August and September 2014 resulted in the following findings:

+ The space in the SCADA room was limited and a phased implementation was required to ensure that both existing and new equipment could be operated simultaneously (Phases 1-3);
+ The support infrastructure (power and cooling) showed multiple deficiencies including:
  o Power distribution:
    ▪ The existing N+1 UPS rated 50kVA had the capacity to accommodate the proposed upgrade. The UPS will be loaded to 95% of its N+1 rated capacity and not offer future additional loads;
    ▪ UPS power distribution panels located downstream of the UPS were not capable of accommodating the planned upgrade.
  o Cooling:
    ▪ The six ton cooling system did not have sufficient cooling and it was interconnected to the base building HVAC. The HVAC system was neither efficient nor capable of providing concurrent maintainability as required by the SCADA system. The cooling system could not accommodate the proposed upgrade;
    ▪ A number of conduits which had no connection to the data centre’s operation were present in the SCADA room ceiling. The raised floor in this space contained unrelated conduits and IT cable management raceways.
+ Structural limitations:
  o The raised floor system was engineered and installed over 10 years ago. It was originally designed to support the old rack system. The new structural burden was greater than the capacity of the existing flooring system.
3.2 Base Building Refurbishment

The deadline for design of the North Service Centre was summer 2015, six months after completion of the SCADA data centre redesign, which posed for a tight schedule.

All architectural, structural, mechanical and electrical aspects of the SCADA computer room design had to be designed as a 100 per cent standalone system which could not be impacted by the upcoming base building redesign.

4. Management of Risk

The design was based on an aggressive schedule corresponding to EPCOR’s needs. To limit delays related to procurement and the potential for construction delays, EPCOR involved the Mission Critical Facility contractor early in the design process. The objective for this decision was to reduce risk through the whole project.

Contractor input was factored in at 50% completion of the detailed design to ensure that constructability aspects of the project would be validated prior to initiation of the demolition activities.

Phasing diagrams were produced in coordination with the general contractor and EPCOR’s SCADA team and resulted in the implementation of construction in four phases:

- Phase 1: Addition of portable cooling units and procurement of all required systems for Phase 2 and 3. Installation of temporary racks for pre commissioning and testing of the new system. Demolition of dropped ceiling and installation of temporary tarps and walls to protect active SCADA equipment;
- Phase 2: Demolition and construction of half of row No. 1 and complete refurbishment of AC system;
- Phase 3: Demolition and construction for remaining part of Row 1;
- Phase 4: Demolition and construction of Row 3;

The phased implementation resulted in better control of the construction steps. Implementation of the environmental control system (temporary cooling and dust barriers) was integrated into the construction phasing to ensure that all existing IT systems would not be adversely affected.

5. Innovation

5.1 Structural Re-enforcement

The SCADA computer room was first engineered more than a decade ago and its infrastructure is now outdated. The raised floor was used as a wireway. Decommissioning and removing the raised floor system was not considered a viable option since the floor supports existing IT equipment which cannot be taken off line. To meet the new structural burdens a raised floor modular re-enforcement system was designed based on readily available kits manufactured by Hilti.

Small galvanized steel beams and columns were installed underneath the raised floor to support the structure. The installation and design was completed with the intention of alleviating the partial demolition of the existing sub floor structure.

All structural augmentations were installed in between existing sub floor stands to support the new rows without down time for the existing equipment.
5.2 New Lighting System

A LED based system for room lighting was specified including LED strip lights within the contained hot aisles, LED heads for emergency battery packs and exit signs, and LED cluster for the new suspended luminaires. The use of LED technology has reduced electrical consumption by 66% and improved to a drop in heat rejection which has improved the maintenance of conditioned air within the SCADA room.

5.3 Cooling System

A portion of electrical power delivered to energize IT loads in a data centre ends up as waste heat. This heat must be removed in order to maintain the temperature within the SCADA room and prevent the IT equipment from overheating. IT equipment is air-cooled, meaning that each piece of IT equipment takes in ambient air and ejects waste heat as exhaust air.

The SCADA data centre contains dozens of IT devices. These devices create a large number of hot air paths within the data centre that must be removed. The purpose of the air conditioning system for the data centre is to efficiently capture this complex flow of waste heat and eject it from the room.

5.3.1 Existing System: Room Cooling

The existing system was based on one ceiling unit tied to the building’s HVAC system and one standalone direct expansion floor standing cooling unit. The room conditioning was ineffective and inappropriate for the proposed next-generation SCADA data centre refurbishment.

5.3.2 New System: In Row Cooling and Air Containment

In a lightly loaded data centre the CRAC power losses could exceed the IT load power consumption. Well defined and controlled airflow paths can allow the facility owner to achieve significant operating savings.

Based on this principle, a combined containment and “In row” oriented cooling architecture was developed to address the problem of capturing and managing hundreds of hot airflow paths in the most efficient manner. The strategy was to capture hot air streams directly at the point of their source.

Figure 4 and Figure 5 reflect the solution implemented for the EPCOR SCADA room. CRAC unit density was increased around cabinets where the highest heat output occurs (Blade server enclosures). The hot aisle containment associated with the CRAC layout maximized the rate of capture of all hot air streams emitted by each IT appliance.
As identified in the blue and green circles in Figure 4, this row-oriented design comprising an aisle containment system, allows cooling capacity and redundancy to be targeted to the actual needs of each row. Compared to the existing room-oriented architecture, the new system recommended by CIMA+ allows for shorter airflow paths. As a result, airflows are much more predictable, all of the rated capacity of the CRAC can be utilized, and higher power density can be achieved.

The reduction in the airflow path length reduces the required CRAC fan power, and thereby increasing efficiency.

6. Advancement of Technology

The use of proven and readily available technologies for segregating the SCADA computer room cooling from the Base Building HAVC system resulted in a significant reduction in the quantity of energy used by the SCADA IT system through the use of an optimized in-row cooling system.

Figure 6 shows a comparison study published by APC. It demonstrates how usable capacity varies for the three different cooling architectures as a function of rack power density. This comparative study was used as the basis of the design for the SCADA room since the study parameter corresponded to a system very similar to EPCOR’s SCADA system.

Figure 6 – Useable Air Conditioner Capacity

Figure 7 – Annual CRAC Electrical Costs

Red line: SCADA room averaged peak density per rack

Figure 7 shows how density drives up electrical costs because it dramatically drives down the efficiency of conventional air conditioning systems.
7. Added Value

Access control was already installed by EPCOR to protect the existing SCADA system. However, no monitoring system was available to ensure that both the SCADA system and its power and cooling infrastructure were operating within expected nominal conditions.

CIMA+ designed a scalable monitoring and control system based on Schneider’s APC InfrastruXure platform. This system collects, organizes and distributes critical alerts and key information, providing a unified view of complex physical infrastructure environments from anywhere on the network. It monitors and controls the Humidifier, Cooling system (CRAC), Power distribution System (PDU and e-PDU), and Leak detection system.

This system provides a web enabled Human Machine Interface (HMI) allowing only authorized operators and contractors to monitor, troubleshoot and control the supporting infrastructure of the SCADA system. It is programmed to interface with the Building Management System (BMS) to provide a “general alarm” in the event that one of many parameters were not within range. Upon receiving the general alarm notification, operators can log online to the InfrastruXure system to receive a full diagnostic overview of the sub system requiring attention.

The system is fully redundant and secured. It constitutes an independent control and monitoring platform unrelated to the base building BMS to prevent an untrained operator from accidentally shutting down critical components.

This advanced warning and troubleshooting system provides the opportunity to specifically identify the problem and required mitigation strategy. The contractor can be dispatched more efficiently on site and immediately proceed to implementing all required corrective actions. This will result in operational savings due to faster troubleshooting.

8. Environmental Value

The new power and cooling infrastructure supporting the IT system was designed to implement the industry’s latest recommended practices:

- The cooling system can be adjusted to set the cooling air temperature and still remain within the ASHRAE recommendations of 18°C to 27°C;
- The system was set to allow the room temperature to rise to 22-23°C in Phase 2 and 3 when both new and legacy equipment would be operated concurrently;
- Upon completion of Phase 4 all legacy systems will be removed and EPCOR will be able to observe the performance of its IT equipment and then increase the setpoint temperature to 27°C. The ability to run modern equipment at higher temperatures will reduce the overall energy required for cooling.

The new system is operated and running independently from the base building HVAC system. This results in additional energy savings, as well as enhanced operational flexibility (maintenance on the base building does not negatively impact the Data Centre.)

Overall, combined with the technological choices selected for the cooling solution, the new system will outperform the old cooling infrastructure, and result in significant savings both economically and environmentally. The carbon footprint of the site will decrease over the site’s life cycle (approximately 10 years for the cooling and power distribution system).
9. Benefit to Society

The technological choices for this project were made to reach the highest achievable uptime. The topology of the redundant power distribution system and cooling system was selected to allow the operator to proceed with concurrent maintenance operations without shutting down the SCADA system.

Since the life cycle of IT equipment is shorter than the infrastructure (cooling and power distribution system) supporting it, all racks were specified to comprise dual cable (corded) management chases allowing for easy reconfiguration for future IT upgrades. Equipment can be added or replaced with minimal efforts in the rows. All mechanical and electrical systems' employs modular connectors allowing for quick connection/disconnection of equipment.

Greater reliability of the SCADA data centre's supporting infrastructure with concurrent maintainability attributes will result in EPCOR experiencing a significant decrease in unplanned shutdowns. This will benefit in better continuity of service and fewer technical mishaps for the clients which EPCOR serves.