Retro-Commissioning Increases Data Center Efficiency at Low-Cost:

Success at Savannah River Site (SRS) at Low-Cost

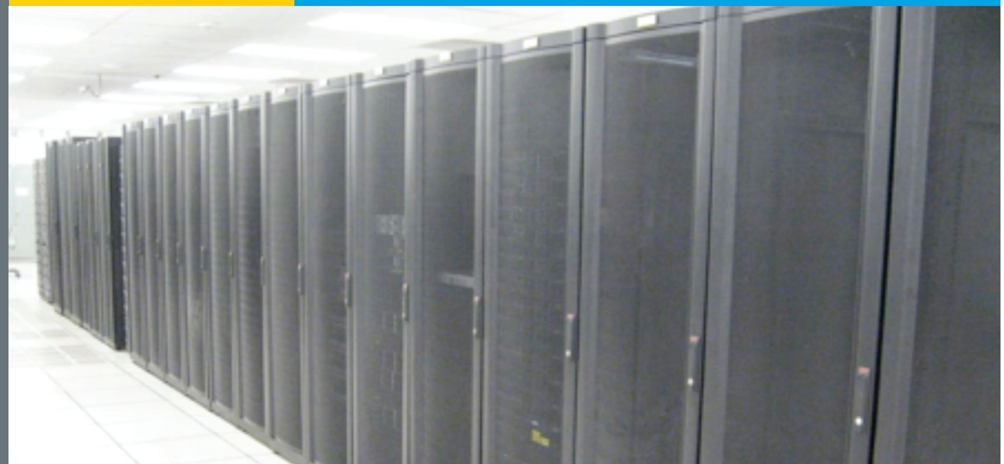

Figure 1: Extended Server Rack at SRS.
Photo Credit: Fred Stanland

As computing capacity within a data center shifts, their managers should ensure that its support infrastructure adapts accordingly in order to realize energy savings. Computing information technology (IT) servers and devices continue to advance and consolidate operations. These improvements can result in reduced space requirements for hardware and increased energy efficiency for computations. Therefore, data center operators can effectively reduce overall data center energy consumption by implementing a recalibration of infrastructure requirements on a regular basis. The Savannah River Site (SRS) data center is a good example of one such facility where this implementation resulted in energy savings.

Evolving Data Center

Over time, the IT equipment inside the SRS data center evolved to accommodate hardware consolidation and meet changing computational needs; however, the data center architectural enclosure and its infrastructure for conditioning the space has remained constant. SRS established a program to pursue energy savings to "green" their data centers that would be cost effective and have minimal impact on critical data center operations. To achieve energy savings, the first step taken in the SRS program addressed retro-commissioning.

Retro-Commissioning

In general, retro-commissioning (Retro-Cx) is a systematic, documented process for identifying operational and maintenance improvements to enable existing buildings to achieve their design intent. The retro-commissioning process can be applied to existing buildings that have never been commissioned or to buildings that have already been commissioned in order to restore them to their optimal performance[1]. The retro-commissioning activities at the SRS data center focused on reducing energy use, improving space conditions, and bringing the facility up-to-date with the newest and best practices while maintaining or improving uptime stability (Figure1).

SRS Retro-Cx Solutions

After reviewing the data center's infrastructure and conditioning systems and collecting energy data, a variety of issues were recognized that were prohibiting efficient operation of the computer room air handlers (CRAHs). Simple, low-cost solutions were identified that could be easily implemented to mitigate these issues. The list of simple operational

Energy Savings Achieved at SRS

Basic Retro-Cx:

1. Eliminated electric reheat.
2. Turned off humidification devices.
3. Tuned floor tile airflow.
4. Turned off three CRAC units.

Total estimated savings ≅ 1,400,000 kWh/year

Retro-Cx cost at SRS:

Engineering consultant: preliminary, on-site, and follow-up work including data measurements and retrieval.
SRS on-site facilities personnel and engineering support.

Total estimated cost ≅ $25,000

Simple Payback at SRS:

Estimated, at $0.045/kWh = 2.5 months.

[1] *www.green.ca.gov/CommissioningGuidelines/default.htm*

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and configuration solutions, which were eventually implemented, included:

- All CRAHs electric reheat coils and humidifiers were disabled.
- Three CRAHs were permanently disabled.
- Supply air floor tiles were rearranged to distribute air more efficiently.
- Some floor tiles were removed to maintain under-floor static pressure.

SRS Retro-Cx Experience

An engineering consultant conducted a preliminary Retro-Cx walkthrough at SRS. Next, a commissioning agent developed guideline procedures for measuring initial energy consumption versus final energy consumption. Using these guideline procedures, initial energy consumption readings were manually gathered by reading uninterruptible power supply (UPS) meters and by using clamp-on ammeters that measured the amperage draw of major infrastructure components and conditioning devices. Once the baseline energy-use conditions were established, a comprehensive heat load distribution analysis was conducted of IT racks, server clusters, and the under-floor air distribution plenum.

Data logging to identify deficiencies

In addition to manual energy measurements, automatic data-logging sensors were installed to measure and record the temperature and humidity conditions before, during, and after the Retro-Cx. The gathered data were analyzed to support a Room Verification Test (RVT) that documented space temperature and humidity deficiencies.

Comparative metering approach

Energy consumption readings were repeated after Retro-Cx changes were implemented using the same approach taken during the initial data gathering. By comparing these two sets of data, the commissioning team was able to calculate net energy savings. It is important to note that the data loggers provided a verifiable information record for the data center operators to quantify the energy savings after the Retro-Cx solutions were implemented.

Site information

The SRS data center is an independent structure that contains support space surrounding the main server "white" space, referred to as the Central Computing Facility (CCF).

Mechanical Systems

SRS is served by two air cooled chillers. Chilled water is distributed by six pumps to the CCF CRAHs. The CRAHs supply cold air to the CCF and selected auxiliary support spaces, such as the UPS room.

Electrical Systems

SRS is provided with electrical power by two 13.8kV transformers connected to the main switchgear. Critical IT equipment power is dual-fed through two 225kVA Liebert UPS systems, which provide up to 20 minutes of backup power. Standby power is supplied by two 1250 kW diesel generators that are connected to the main CCF switchgear with an automatic transfer switch.

Climate

SRS is located near Aiken, South Carolina, which has a mild, subtropical climate with temperatures ranging from an average of 45°F in January to 81°F in July. Humidity ranges from an average of 85 percent in the mornings to 50 percent in the afternoons all year[2].

Retro-Cx Process

The Retro-Cx process commenced on June 2nd, 2010, and lasted for three days. The process was split into three phases, one for each day. Day 1 included the initial setup and baseline creation, Day 2 involved the actual implementation of operational changes, and Day 3 involved taking final readings to compare and measure the change in energy consumption. The activities of each day are described in detail below.

Day 1 — Initial Data Acquisition and Metering

In order to generate data points for supporting a Room Verification Test (RVT), 20 remote data loggers were placed to monitor the temperature and humidity conditions of the CCF throughout the duration of the three-day effort. These loggers were installed on the first day and were collected at the conclusion of the last day.

- Eight data loggers were installed inside the return ductwork CRAH units located within the CCF.
- Twelve data loggers were installed at the air inlets of IT equipment racks.

A "snapshot" of initial operating conditions was logged for all CRAHs serving the CCF building. Temperature setpoints, operating status, and chilled water valve positions were recorded to establish an operational baseline. These data were compared to the final data collected on Day 3 after modifications to the heating, ventilating, and air conditioning (HVAC) system were completed.

Initial electrical power consumption was measured to establish a baseline. Amperage was measured using service distribution board ammeters and local UPS displays. The measurements were taken by SRS facility personnel. These initial readings included:

- Switchgear for incoming utility power.
- Redundant UPS units for IT load.
- Service distribution boards for mechanical load and miscellaneous loads such as lighting.

Day 2 — Implementation of Operational Changes

Facilities personnel implemented CRAH operational upgrades. Improvements were incrementally tracked by synchronizing upgrade activities with data-logging sensors installed on Day 1. The following changes were made:

[2] www.cityofaikensc.gov/index.php?page=about

- All CRAH electric reheat coils and humidifiers were manually programmed "off" at each unit's control panel.
- Three CRAHs were turned off at the control panel.
- Floor tiles were rearranged to distribute air more efficiently based on analysis of heat load density of IT rack clusters.
- The number of grated floor tiles with high-percentage openings was reduced to compensate for a drop in under-floor pressure caused by permanently disabling three CRAHs (see above).

Day 3 — Final Data Acquisition and Metering

After the data center conditioning systems stabilized, electrical measurements and meter readings were repeated to capture a final, post-implementation "snapshot."

- Data loggers were recovered and their data imported for analysis.
- The data are presented in the next sections of this report.

SRS Retro-Cx Results

The results of the initial electrical power consumption readings are presented on Table 1. The Total Cooling System Load includes consumption by all mechanical support equipment such as chillers, CRAHs, pumps, etc. Each circuit breaker on the main panel board was metered and combined to get the total value of 402.9 kW. The Total UPS Load, Gross Input of 173.6 kW was read from the two UPS modules serving IT equipment. Combing the Total Cooling System Load and the Total UPS Load yielded a Total Load of 576.5 kW.

The net UPS output power provided to the IT loads was 144 kW, which resulted from an efficiency loss within the UPS device of 26.9 kW. This computes to a "snapshot" Power Usage Effectiveness (PUE) value of 4.00, which is to say that 25 percent of the total electrical input powers the IT server racks. Note that by definition, PUE is a basic energy-use metric for gauging the efficiency of electricity allocation by a data center's infrastructure with energy usage gathered over a year's time period. However, in this study, the PUE was calculated as instantaneous power metric — the ratio of the total power consumption of the facility to the net power consumption of the IT servers.

The final results taken on Day 3 are presented on Table 2. It was immediately apparent that the Cooling System Load dropped dramatically due to the shutdown of three CCF CRAHs and disabling of all remaining unit's humidity controls, thus saving power consumption by humidifiers, reheat systems, and chillers. A Total Cooling System Load of 229.8 kW was measured on Day 3. The critical IT load and UPS efficiency loss remained identical since no changes were made to either the IT equipment or electrical distribution sequence, and that both readings were taken approximately the same time of day. The Total UPS Load, Gross Input of 171.9 kW was read from the two UPS modules serving IT equipment.

Summing gross input UPS and Cooling System meter readings, a Total Load of 401.7 kW was recorded as the final value for power consumption. The net UPS output power to the IT loads of 145 kW resulted from an efficiency loss within the UPS device of 26.9 kW. This yielded a final PUE value of 2.77. Therefore after the Retro-Cx, about 36 percent of the total input electricity powers the IT server racks. Compared to the initial 25 percent of the total input electricity powering the IT server racks, an increase in efficiency of 11 percentage points was achieved.

Comparing initial meter readings shown in Table 1 to the final readings shown in Table 2, the changes implemented in CRAH device operation and to floor tiles had a dramatic effect on increasing

TABLE 1 — Initial Power Consumption	
Total CCF CRAH Units	133.2 kW
All Others (Chillers, Pumps etc.)	309.7 kW
Telecom deduction*	(- 40 kW)
Total Cooling System Load	**402.9 kW**
Total UPS-1 Input — for IT Load	96.3 kW
Total UPS-2 Input — for IT Load	77.3 kW
Total UPS Load — Gross Input	**173.6 kW**
TOTAL LOAD	**576.5 kW**
Total UPS-1 Output — net IT Load	77 kW
Total UPS-2 Output — net IT Load	67 kW
Total IT Load — Net UPS Output	**144 kW**
Initial PUE	**4.00**

TABLE 2 — Final Power Consumption	
Total CCF CRAH Units	58.40 kW
All Others (Chillers, Pumps etc.)	211.4 kW
Telecom deduction*	(- 40 kW)
Total Cooling System Load	**229.8 kW**
Total UPS-1 Input — for IT Load	95.2 kW
Total UPS-2 Input — for IT Load	76.7kW
Total UPS Load — Gross Input	**171.9 kW**
TOTAL LOAD	**401.7 kW**
Total UPS-1 Output — net IT Load	78 kW
Total UPS-2 Output — net IT Load	67 kW
Total IT Load — Net UPS Output	**145 kW**
Final PUE	**2.77**

**Note that an estimated 40 kW is deducted from total power consumption of the CCF to account for the portion of chiller capacity that is consumed by the adjacent Telecom building. Other energy use such as lighting, standby generation loss and fuel use was not measured or estimated. This would have a slight negative impact on PUE.*

the overall data center efficiency. The Total Cooling System Load dropped from 402.9 kW to 229.8 kW, a savings of 173.1 kW. The PUE improved from 4.00 to 2.77 from an overall 30 percent reduction of total electrical load.

SRS Retro-Cx Efficiency Benefits

A RVT analysis was conducted using the data collected from the data loggers. Both temperature and humidity were compared using the event time log from the three days of retro-commissioning. By comparing temperature and humidity data, it was found that the critical environment was left intact and stable. The facility's temperature logging system, used by the data center's operating personnel, confirmed this finding as the temperature levels remained well within the industry accepted range. A full analysis, including data and graphs, is available in the retro-commissioning summary report, noted in the References section.

Lessons Learned

The Retro-Cx energy-efficiency project at SRS showed that very basic adjustments to existing CRAH unit functions and careful review and adjustments to floor tiles can result in great improvements in efficiency without large expense. See sidebar titled "Energy Savings Achieved at SRS."

Next Steps

The retro-commissioning team identified additional cost-effective methods that could be implemented to optimize airflow and reduce energy consumption at the CCF. These recommendations include:

- Revise the layout of the ceiling mounted return grilles according to a sketch provided in the retro-commissioning summary report. This should improve air flow efficiency, return air plenum temperature, and overall CRAH efficiency.
- Install isolation dampers or blank-off panels on the three permanently disabled CRAHs. This will isolate the disabled units to mitigate cold air bypassing from the positively pressurized under-floor plenum to the ceiling return air plenum.
- Increase temperature setpoint of CRAH return air. This would allow internally-programmed chilled water valves to throttle closed and lessen chilled water flow volume, thus reducing energy use by pumps and chillers.
- Increase temperature setpoint of chiller water to reduce chiller power consumption.
- Compile a PUE with energy data gathered over a year that includes all efficiency losses of the electrical distribution sequence, such as power distribution units (PDUs), and energy use by supporting devices, such as standby emergency generators.

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