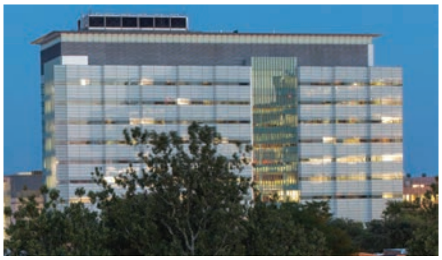
University of Chicago KCBD
Retro-Commissioning

Facility Data: The Knapp Center for Biomedical Discovery (KCBD) is a 330,000-square-foot building completed in 2009. It provides labs, a vivarium, and office space for research groups including the Institute for Pediatric Molecular Sciences, devoted to the genetic influence of childhood diseases.

Scope of Project: G/BA provided retro-commissioning services in two phases between 2014 and 2015.

Project Summary:



Primary heating for the medical campus is supplied by the university's central high-pressure steam plant. Pressure-reducing valve stations and heating hot water converters are located in the lower level mechanical room. Low-, medium-, and high-pressure systems are used for clean steam generation, sterilizer equipment, and humidification. Heating hot water is used for AHU heating coils, terminal unit reheat coils, baseboard hot water heat, radiant heating panels, and fan coil units.

The **chilled water system** is a variable secondary, constant primary configuration served by three water-cooled, electric centrifugal chillers. The total cooling capacity is 3,600 tons. Cooling is provided year-round.

The **ventilation system** includes a total of 18 AHUs. The breakdown of unit types includes four 100% OA VAV units for the vivarium, eight 80% OA VAV units with lab exhaust heat recovery, and six CV units serving mechanical spaces. The building is controlled by a DDC system.

G/BA retro-commissioned the facility as part of the ComEd Smart Ideas incentive program. The first phase aimed to identify and implement low-cost, short-payback energy conservation measures to improve sustainability and reduce operating costs. The second phase focused on larger capital projects. **Though the RCx project targeted energy efficiency, some ongoing operational problems were revealed during early planning.**

Heating problems had given rise to the idea that heating capacity was insufficient. AHUs would often shut down in response to low-temperature safety switches; humidifiers would behave erratically in response to pressure changes; and the steam PRVs required constant maintenance. Extreme negative pressures caused elevators to shut down and lobby curtain walls to frost over. The KCBD was one of the campus's newest buildings, but it had been a nightmare for the facilities staff and operating engineers. They were hesitant to allow the RCx team to propose changes to the critical AHUs or lab exhaust systems.

To model the building steam load, the engineers checked the hot water systems with an ultrasonic flow meter and used trending data from the steam systems. The model suggested that the building had a design capacity of about 177% of the estimated peak steam load. Capacity was ample, but there was clearly some problem with how that capacity was being used.

RCx investigation identified multiple issues that were limiting the capacity of the building heating systems. The steam system and air handling units were both involved. The engineer determined that a holistic approach would be necessary, and that correcting each of these issues individually would not solve the problem.

Each of the eight laboratory AHUs contains a heat recovery coil, return damper (RAD), preheat coil, and cooling coil. Return fans are shared between four paired sets of AHUs. Three issues were identified regarding the AHU temperature control/unit configuration:

- First, the design sequence noted that the when the heat recovery water leaving temperature dropped below 30°F, the three-way control valve was supposed to modulate closed. **Instead of modulating the heat recovery valve to maintain a leaving temperature of 30°F, the valve would actually close quickly.** This resulted in a quick drop in mixed air temperature (MAT) and main heat recovery supply water temperature. The affected AHU would trip off on low temperature, and the other AHUs would trip due to the drop in temperature of the heat recovery fluid temperature.
- Second, each AHU would control its own RAD to maintain the discharge air temperature (DAT) setpoint, while the preheat coil would operate to maintain the preheat coil discharge temperature (PHT) setpoint. This caused **fighting between the two systems: as the preheat valve would modulate open to maintain the PHT, the DAT would be affected, causing the return damper to close.** This scenario was preventing heat recovery of the return air and resulting in low-temp trips. Additionally, if an AHU preheat valve modulated closed, causing a small drop in DAT, the return damper would open. Unfortunately, the AHU return dampers were not pressure-independent, so when one AHU return damper would open, return air would be stolen from the paired AHU. This would again cause a drop in MAT and a low-temp trip condition of the other unit.
- Third, because of the previous issues, **the controls sequence had been modified** to enable the preheat valves when the outside air temperature reached 39°F, and to start the valves 100% open. The AHUs would quickly overshoot the PHT setpoint (and DAT again), and the preheat valve would close. Because the valve was closing but the heating load was increasing as the OAT decreased, the AHU could trip off on the low-temperature limit. Also, all AHUs would enable preheat valves simultaneously, drastically increasing the low-pressure steam demand. The steam PRVs would open up significantly to satisfy the load. The preheat heat exchangers would take most of the steam, and the AHU steam humidifiers would start to open their valves more to maintain humidification. The preheat system load would satisfy quickly because the AHU valves would start closing, and the heat exchanger steam valves would start closing as well. The humidifier valves were then open more than necessary, so the AHUs would start humidifying excessively.

Two more issues were identified with the steam system that limited the capacity of the heating system. First, the preheat hot water heat exchangers were served by 1/3 and 2/3 steam valves. The **two 1/3 valve pneumatic actuators had failed,** forcing the valves closed. The BAS was still commanding the 1/3 valves open, but operators did not know they were closed, since the 2/3 valves were operating correctly. This caused a drop in system capacity.

Second, **the low-pressure steam PRV station was not set up correctly.** The station had three parallel lines, each with a primary and secondary PRV. All secondary PRVs were set to maintain the low-pressure setpoint of 15 psi. The secondary PRVs would often fight each other since they were trying to maintain the same setpoint. This caused large swings at the upstream pressure gauge, contributing to the theory that the campus system was to blame. Through RCx, the PRVs were adjusted to setpoints of 15 psi, 13 psi, and 11 psi, allowing them to stage properly.

Energy Efficiency: All of these issues led to unstable heating and steam systems. Correcting these issues allowed the heating system to use return air and the energy recovery system to improve energy efficiency. **Annual savings of 88,000 therms were verified.**

Operations and Maintenance: O&M was drastically improved by steadying temperature and pressure control, reducing the amount of AHU shut downs from low-temperature safety switches and reducing wear on the steam PRVs.

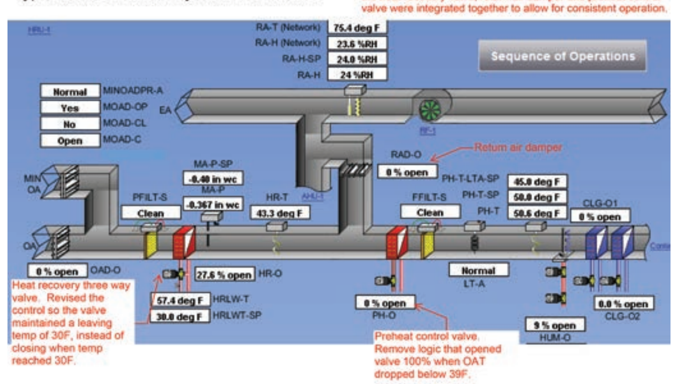
Indoor Air Quality: Corrections led to a significant improvement in the stability of the HVAC systems and proper filtration and control of ventilation air.

Innovation: Initially, the owner assumed that an extreme design change would be necessary. However, by discarding a prescriptive RCx approach, and tackling issues holistically, the engineer was able to use detailed site investigations and data analysis to make the building work with the existing equipment.

Cost Effectiveness: Phase I was funded by ComEd and resulted in **verified savings of $106,000 per year** with a payback of less than a year. Phase II found additional low-cost controls modifications and equipment repairs that could improve the building operation instead of major design modifications.

Typical AHU Controls System Screenshot

In addition to the modifications described below, the control of the heat recovery valve, return air damper and preheat control valve were integrated together to allow for consistent operation.



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