Context

Thunder Bay Regional Health Sciences Centre (TBRHSC) is a state-of-the-art acute care facility serving the healthcare needs of people living in Thunder Bay and northwestern Ontario. As the hub for a population base of approximately 250,000 people, the facility houses 375 beds within 686,000 square feet.

While TBRHSC was constructed in 2004 in a cost-effective and innovative manner, the technology and environmentally friendly options have advanced since its original design. Given this evolution, there were more opportunities and an incentive for TBRHSC to look at improving the operating efficiencies and costs for the facility while also reducing its environmental footprint.

Challenge

To better understand the facility’s energy use, an energy balance was conducted which showed that the HVAC loads in the form of heating loads, fans and pump energy, were the largest contributors to energy use.

The result was an energy reduction program that included boiler burner controls upgrades, heating pump variable flow conversion, thermal insulation for the heat recovery tank, modifications to the ventilation and control systems, the cooling tower, and a heat exchanger upgrade.

This case study focuses on the modifications made to the ventilation and controls systems. This phase of the project moved many of the primary energy-consuming environmental systems from “constant” to “on-demand” functionality. The objective of the project was to maintain the level of ventilation required under the current ventilation standards for hospitals without over ventilating, thus reducing energy consumption and greenhouse gas emissions.
Solution

Air Handling Unit (AHU) Occupancy Scheduling
Given that the ventilation systems at TBRHSC were running continuously regardless of the type of use that occurs in the space being ventilated, modifications were made to adjust the operation of the various ventilation systems, which included a combination of scheduling fans to turn off during unoccupied hours, conversion to variable air volume controls and zone-based occupancy controls, while still operating within the parameters outlined in CSA Z317\(^1\). New variable speed drives, inverter duty motors and static pressure controls to adjust fan air flow were installed as needed. Programming changes at the affected AHUs were made to incorporate variable air flow controls and start/stop scheduling into the existing control strategies. Programming changes were made where applicable at the identified terminal unit controls to enable zone-level occupancy schedules and variable air flow controls. The installation of the equipment was relatively straightforward, but the scheduling and programming of the system to optimize the effectiveness of the AHU units, energy savings and to meet space requirements took more effort in order to ensure all stakeholders including hospital staff were on board.

Re-commission AHU sequences
TBRHSC established a checklist of functions to ensure that each of the components of the facility’s ventilation systems are operating as expected and are able to achieve the desired control set points. Each AHU in the facility was first checked for proper operation, adjustments to operating set points were made to ensure proper sequencing of the equipment and any defective equipment that was identified during this process was repaired by the maintenance personnel. A group of 100 or 10% of the terminal units (TU) were re-commissioned to determine the accuracy of control being achieved. Based on the initial TU test results, additional remedial action was required for some of the TUs – i.e. valve repair or replacements. In addition, one reheat coil at each TU was inspected to evaluate the cleanliness of the ventilation system. Any systems that showed excessive blockage at the coils were cleaned.

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1 Canadian Standards Association (CSA) Z317.2-15 Special requirements for heating, ventilation, and air-conditioning (HVAC) systems in health care facilities
Fume Hood Controls
The fume hoods were configured to exhaust a constant amount of conditioned air whenever the exhaust fan is in operation. The correct movement of air is required to direct contaminants away from the users who are positioned in front of the hood. The air was flowing through the open sash or through the bypass when the sash was closed. To improve on this system, a set of controls was installed to allow the amount of exhaust air to be adjusted based on the position of the sash. Sensors were installed at each hood to track the position of the sash while the bypass vent was blocked. The signal from the sash sensor caused a dedicated air valve installed in the exhaust duct to close or open as required in order to maintain a safe air velocity at the sash opening. The speed of the corresponding exhaust fan was adjusted accordingly to maintain the correct static pressure across the fan.

At the core lab location, where a dedicated supply air terminal unit provides ventilation air to the room, a differential pressure sensor was installed to adjust the air flow entering the room to maintain a negative pressure in the room relative to the adjacent corridor. The ventilation air at the other locations was supplied via a transfer grill. The relative pressurization of the room remains negative as less air is drawn in through the grill.

Operating Rooms Ventilation Controls
The ventilation systems serving the operating room (OR) suites and the angioplasty rooms operated continuously; they were configured to provide ventilation at the rates required by CSA Z317\(^2\) during procedures. The ventilation standards allow the rates to be reduced during periods when there is no procedure taking place as long as the pressurization of the suites is maintained positive relative to the adjacent corridor. The installation of volume control boxes at each of the 14 OR suites combined with differential pressure sensors allow the pressurization of the rooms to remain positive. Occupancy sensors allow the system to switch between full ventilation and stand-by ventilation whenever the suites are in use for a patient procedure. Two AHUs were equipped with variable speed drives and static pressure sensors to enable the fans to adjust the air volume being delivered to the suites based on occupancy. The dedicated AHUs serving the angioplasty rooms were equipped with variable speed drives as well, but the speed of the drives was based on scheduled use of the corresponding rooms. Both the OR suites and angioplasty rooms are now ventilated at the same rate to maintain the relative pressurization.

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2 Canadian Standards Association (CSA) Z317.2-15 Special requirements for heating, ventilation, and air-conditioning (HVAC) systems in health care facilities
Building Control Optimization

The Facility Performance Indexing (FPI) software package, which communicates with the existing building automation system, determines the reliability of existing control signals and the quality of control that is in effect. Monitored parameters such as zone temperatures, actuator commands and measured air flow are tracked over time and evaluated as to whether they are being effectively controlled or remaining within expected parameters. In the event that a monitored point drifts outside the expected operating range, a visual indication is provided at the FPI dashboard interface. This dashboard interface allows the building operators to quickly identify areas of the facility that are operating outside the expected range of operation, and thus enables a proactive approach to maintaining the control system. This software gave the building system operators additional tools to monitor the building performance – overall and by area. Training and buy-in from the operators was, and continues to be, key to successfully implementing this tool.

Results

As a result of this project, an electrical energy reduction of 3,128,902 kWh was achieved after the first year: this was a 14% reduction versus the reduction target of 20%. Gas reduction was 937,063 m³ after the first year: this was a 19% reduction compared to previous year, exceeding the 16% reduction target. Moving ventilation and control systems from “constant” to “on-demand” functionality, has decreased TBRHSC’s annual utility costs by $535,000 and CO₂e emissions by 2,115 tonnes.

Other results include:

- The reduced utility costs allowed dollars to be directed to additional environmental improvement initiatives
- Identified future retrofit projects (e.g., lighting, more heat recovery, heating and cooling plant optimization, and building envelope)
- Addressed other issues at the same time (i.e., discovering issues/operations that weren’t optimal and adjusting these)
- Improved troubleshooting and monitoring of energy savings through FPI
- Reduced maintenance costs due to extended equipment life and better equipment control (e.g., variable frequency drives extended the life of the motors)
- Reduced the number of temperature complaints from staff
- Increased operations and maintenance staff capability and expertise
Learnings

**Actual Savings versus Targets:** The electricity reduction target of 20% was not met, partially because the hospital experienced a load increase due to new equipment that arrived after the baseline was established, and also because the heating system control and the AHU scheduling were not optimized in some cases, and may have been aggressive when the project was planned. The building system operator continues to optimize the efficiency of the AHU to meet the reduction target.

**Occupancy Scheduling:** Fan schedules continue to be an obstacle in meeting expectations as staff are not fully comfortable with the changes. As well, due to large zone impacts, the operator is not able to adjust each area optimally. The initial intent was to turn selected fans off, however, there were zoning issues which led to the decision to schedule the variable air volume boxes on occupancy schedules. In this scenario, the fans run at reduced capacities during the unoccupied hours. The facility team surveyed the building for scheduling potential and selected areas where occupants are open to further adjustments and improvements.

A more aggressive and continuous approach to scheduling is needed - fans supplying areas that are not occupied 24/7 should be scheduled to turn off, and areas supplied by fans which serve zones with varying occupancies need to have their schedules revised. The reduced air strategy may be able to implement schedules on fans not originally selected for scheduling. There were schedules which were extended during the winter because of the cold weather, but they need to be reinstated when the requirement for additional runtime is eased. Additionally, zone temperature set points need to be limited within a reasonable range for occupancy comfort, keeping in mind the energy savings goals. This measure requires cooperation from occupants and will require continued effort to implement.

**Lab Fume Hood Controls:** Two labs which were chosen for the project were unable to be retrofitted for regulatory reasons as they were used for biological samples. They were provided with stop/start control instead of the venturi valve/variable positioning control.

**Staff Reception to Lab Fume Hood Controls:** Ensure the use of hoods is well understood by lab staff before making any retrofits. There may be no benefit if staff leave the hoods open or switched on.
Facility Performance Indexing (FPI) implementation: FPI implementation was delayed because of system compatibility issues. FPI is an indexing program which polls information from the building automation system (BAS) that has the capability to work with third-party systems provided that BAS is BACnet (Data Communication Protocol for Building Automation and Control Networks) capable. Since the hospital BAS system did not have an existing BACnet server, this made the integration challenging as the necessary points had to be aligned manually into the FPI database.

Non-Energy Benefits: More attention could be paid to quantifying the non-energy benefits of the project. Only high-level qualitative assessments of the benefits were provided when it could have been possible to provide more quantitative assessments in many cases.

What You Can Do

- The buy-in from physical plant/facilities staff and end-users is critical up front.

- A good understanding of the hospital’s HVAC current state and its challenges is beneficial in determining the ideal solution.

- Take advantage of the capabilities of the automated controls systems to allow the building operators to fine tune the ventilation system to match the use by the occupants. Monitoring and diagnostics help to protect occupant comfort, while achieving the energy savings targets.