Aurora Medical Center, Grafton, Wis., is the first LEED certified hospital in the state. Energy recovery chillers and reduced fan horsepower are the main contributors to the facility's low energy consumption.

Reheat for Medical Center

By **Mike Lawless, P.E.,** Associate Member ASHRAE

The challenge for the design team of the new Aurora Medical Center in Grafton, Wis., was providing a LEED Silver hospital while demonstrating a payback of the additional first cost. Energy efficiency was the main driver of the cost savings that would demonstrate the payback. The design team targeted areas of highest energy use in standard health-care facilities, including fan energy, reheat, heating/cooling plant energy and lighting and then optimized the savings compared to first cost for a series of energy-efficient options. The goal was not to save as much energy as possible regardless of the cost, but to save a significant amount of energy in a cost effective manner. The result is a building that can be optimized to provide more than $340,000 in annual savings with a simple payback of less than four years.

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Energy Efficiency

To verify system operation and comply with LEED requirements, measurement and verification (M&V) was completed. The M&V process entailed tracking the energy use of the facility for one year to ensure savings predicted in the energy model were being realized. The M&V showed the building was using less energy than anticipated in the energy model and consuming 25% less energy than allowed by ASHRAE Standard 90.1-2004, with a recorded energy use of 207 kBtu/ft^2·yr (2 350 899 kJ/m^2·yr). *Figures 1* and *2* show the monthly energy consumption of the building compared to the baseline energy model.

To achieve the savings, the team focused on reducing fan and reheat energy, designing an efficient heating/cooling plant, specifying high efficiency lighting and optimizing use of the energy recovery chiller.

Fan Energy

Custom air-handling units, coils, and filters were sized to maintain a maximum face velocity of 350 fpm (1.8 m/s). This reduces pressure drop and fan horsepower consumption for the life of the building, also reducing noise levels to provide a healthier acoustical environment.

Innovative filters within the air-handling units use advanced pleated technology that allow air to travel through larger filter surface areas in smaller housings, while lowering overall pressure loss.

Air-handling unit fan system effect was reduced by properly designing an evase at each supply fan discharge. This gradual transition to the supply duct system accounted for static pressure reductions and overall fan size reduction.

In addition, much of the facility's ductwork was sized at no more than 0.1 in. w.c. (24.9 Pa) friction per 100 ft (30 m) of duct to facilitate lower pressure drop within the entire duct system.

The reduced fan horsepower showed significant savings when compared to typical hospital designs and also showed savings when compared to the Standard 90.1-2004 baseline system. When comparing the fan horsepower to a conventional design, a savings of more than 200 hp (149 kW) was calculated.

Reheat Energy

Energy recovery chillers were installed to transfer energy from the hospital's chilled water loop to the heating water loop, rather than rejecting it outdoors. Domestic hot water and boiler feed water, in turn, were preheated by the heating water via a double-wall heat exchanger.

Providing heat from the energy recovery chiller was less expensive than boiler heat, even when cooling was not needed. When both heat and cooling were needed, the economics were extremely favorable. To take advantage of this, chilled water fan coil units were used in lieu of overhead air to cool energy intensive spaces (data centers, imaging equipment rooms, etc.). In addition, chilled water coils were added to the exhaust airstream to harvest energy from the exhaust air during the prolonged cold periods in Wisconsin. By maximizing the year-round chilled water load and sizing the energy recovery chillers to match, the payback for the energy recovery chillers was optimized to three years.

Occupancy control in health care is an important step to reduce fan and reheat energy. Reducing air change rates in unoccupied areas such as operating rooms reduced the fan and reheat energy. Occupancy control also was provided for office and other support areas to minimize energy use during unoccupied periods.

Heating and Cooling Plant

A variable primary chilled water system with a 14°F (7.7°C) ΔT minimized pumping energy was installed. Also, efficient centrifugal chillers were chosen and the chilled and condenser water temperatures optimized for energy savings and first cost.

High-efficiency vertical water tube boilers were provided with stack economizers to preheat the boiler feed water. The low-water volume within the boil-

Atrium at Aurora Medical Center.

Building at a Glance

Aurora Medical Center Grafton Wisconsin

Location: Grafton, Wis.

Owner: Aurora Healthcare

Principal Use: Hospital

Includes: 107 patient rooms; 18 operating rooms; compounding (USP 797 compliant) and retail pharmacy; imaging equipment including X-ray, MRI, CT; four cardiac catheterization labs; nuclear medicine; laboratory, atrium

Employees/Occupants: 594 full-time employees, 494 visitors, 80 patients

Gross Square Footage: 526,000

Conditioned Space: 526,000 ft^2

Occupancy: 95%

National Distinctions/Awards: LEED Silver ers provided notable energy savings by requiring less natural gas during standby periods.

Lighting

High-performance lighting systems reduced the building's lighting power density by more than 25% when compared to the Standard 90.1-2004 baseline. This reduction also decreased the cooling loads in the spaces, reducing overall demand on the chillers.

Lighting controls were used in some locations to automatically turn off unused lighting and lighting in common spaces, and occupancy sensors turned off lights in vacant rooms.

Daylight harvesting was used in locations near exterior windows to reduce lighting loads during the day.

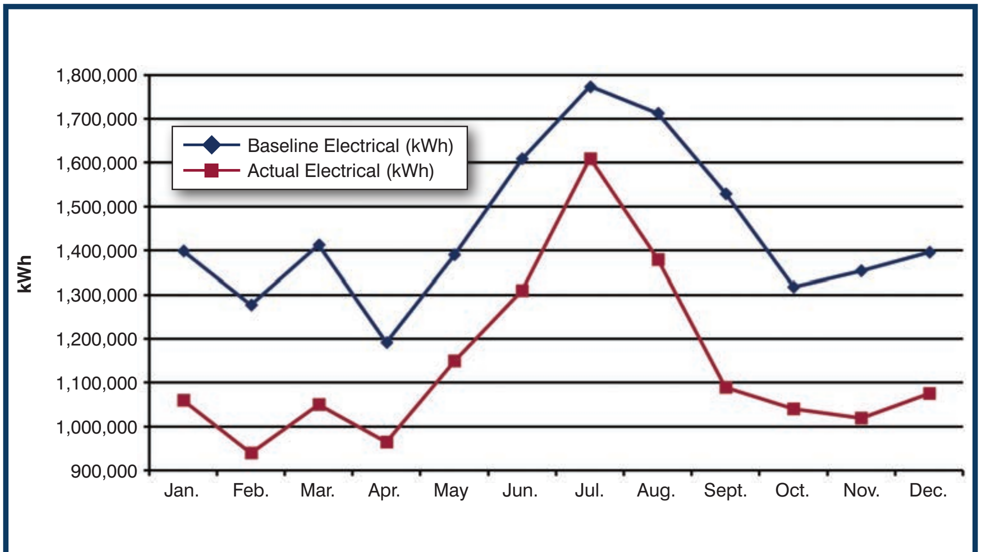

Figure 1: Monthly electrical consumption.

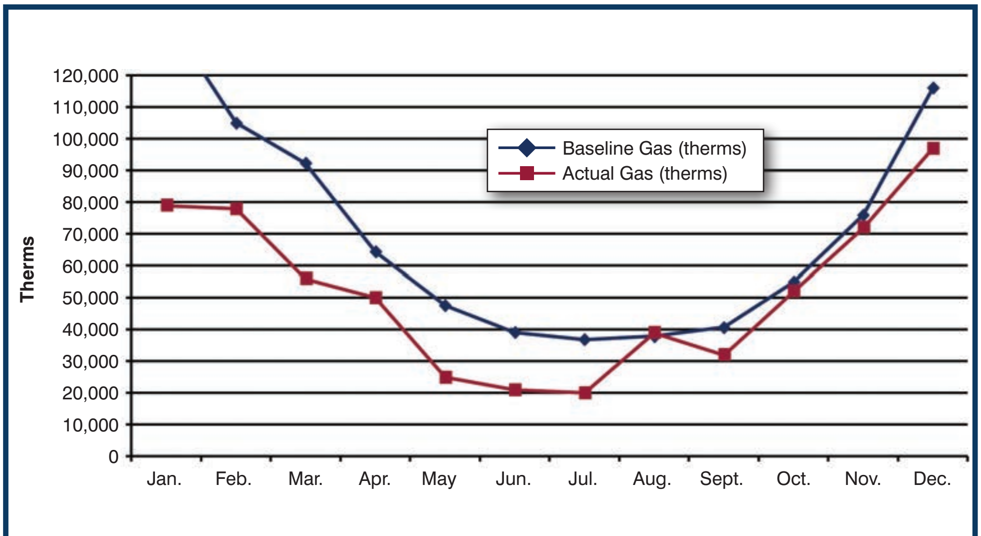

Figure 2: Monthly gas consumption.

Optimizing Energy Recovery

The cold climate in Wisconsin leads to fewer hours of typical chiller plant operation, which can result in an increased payback period for energy recovery chillers. To improve the payback period of the energy recovery chillers, several exhaust energy recovery units (EERUs) were added to take heat from the exhaust airstreams and transfer it to the chilled water system. This energy is transferred through the energy recovery chillers to the heating water system. The EERUs only recover heat when the chilled water load is not adequate for the energy recovery chillers to satisfy the heating needs of the building. The EERUs replaced exhaust fans with a unit containing a fan and chilled water coil. This allowed the engineering team to economically expand the operation of the energy recovery chillers and reduce the payback period.

The energy recovery chiller sizes were optimized with this strategy, as shown in *Figure 3*. (The energy recovery chillers at the Aurora Medical Center were highlighted in the *Advanced Energy Design Guide for Large Hospitals* as an innovative and effective strategy to save energy in health-care facilities.)

Indoor Environmental Quality

Occupant comfort levels specifically targeted indoor air quality, building acoustics, and thermal comfort. The ventilation air design meets ASHRAE Standard 62.1-2004 requirements, as was verified via the LEED certification process.

All spaces were provided with a minimum of MERV 14 filtration, and the surgery and pharmacy suites were provided with HEPA filtration. Many building spaces, including the laboratory, airborne infection isolation rooms, storage rooms, copy rooms, janitor's closets, and other hazardous areas that could produce contaminants within the building were fully exhausted to the exterior. Increased filtration and exhaust led to enhanced indoor air quality, which improves occupant health and comfort. Indoor air quality was further improved by using low-emitting sealants, paints, and carpeting in the facility.

The building acoustics were reviewed extensively to ensure occupants did not find HVAC distracting or uncomfortable and that

Advertisement formerly in this space.

patient privacy was maintained. Duct silencers were integrated in the rooftop air-handling unit curbs to ensure noise from air-handling systems was addressed before the ductwork entered occupied spaces. Fans also were quieter, due to the lower air velocities used to reduce pressure loss in the system. Additionally, in areas of concern, heavy (14 gauge) ductwork was used to eliminate potential breakout noise from ductwork within the building.

The HVAC systems were designed to meet thermal comfort levels as defined by ASHRAE Standard 55-2004. A variety of rooms, occupant activity levels (met), and clothing levels (clo), were modeled to ensure occupants would be comfortable and the space would be maintained at 72°F (22°C) and a minimum of 30% RH year-round.

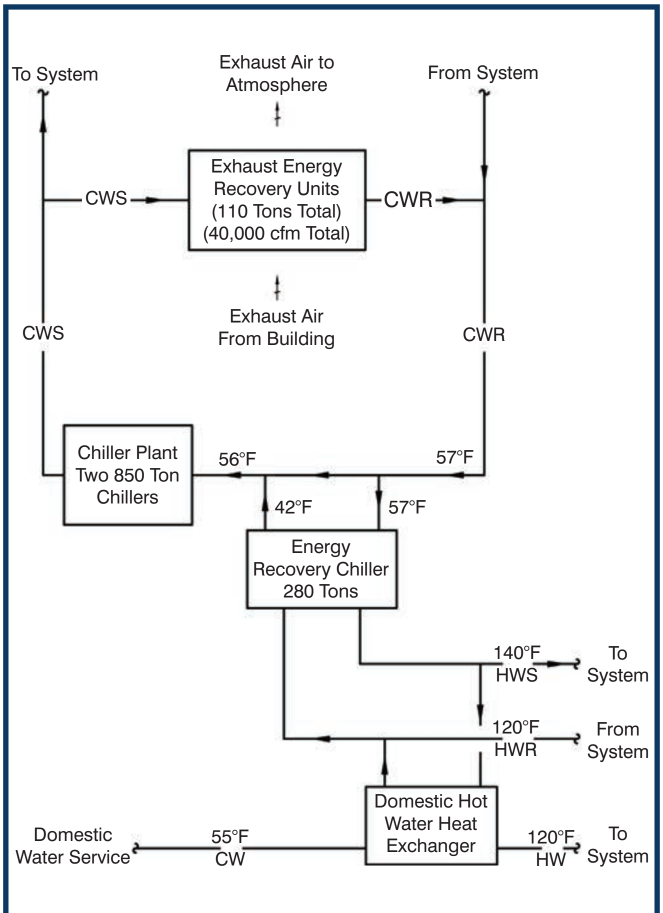

Figure 3: Exhaust energy recovery unit and energy recovery chiller optimization.

Maintenance & Operation

While comfortable with the VAV reheat systems used throughout their network of facilities, the owner also was interested in improving energy efficiency. To address this need without drastically changing maintenance requirements, energy recovery chillers and other improvements were added to supplement their typical systems.

The high-efficiency water tube boilers require less maintenance, are easier to operate, and do not require large access typical of conventional fire-tube systems.

The HVAC, domestic water, and lighting control systems were commissioned to ensure proper operation, calibration, and performance prior to the owner taking occupancy. A number of opportunities were addressed to ensure the owner was provided with a high-performance facility that reduced operating costs and increased occupant productivity.

Environmental Impact

The verified energy performance of the building compared to the code baseline indicates an annual greenhouse gas emissions savings of 2,500 tons of carbon dioxide. In addition, electrical savings could power 200 typical homes in the community. The natural gas, electric, and water savings not only save substantial facility resources, but savings also are realized at the off-site natural gas, electric, and water utility plants.

Component	Initial Cost	Yearly Savings	Payback Period
Low Flow Plumbing Fixtures (33% reduction)	$28,000	$8,000	3.5 Years
AHUs and Ductwork Sized to Exceed Standard 90.1-2004 Fan Horsepower Requirements	$500,000	$100,000	5 Years
Chilled Water Cooling	$50,000	$14,000	3.5 Years
Energy Efficient Boilers	$240,000	$60,000	4 Years
Energy Recovery Chillers	$360,000	$120,000	3 Years
High Performance Lighting	$0	$21,000	N/A
Room Occupancy Monitoring	$55,000	$21,000	2.5 Years

Table 1: Energy-efficiency improvement payback.

Conclusion

By designing and implementing creative and innovative solutions to the building's challenges, the design team was successful in meeting the goals of the Aurora Medical Center. The installed energy-efficient equipment can be optimized to provide more than $340,000 in annual savings with a simple payback of less than four years (*Table 1*). Also, throughout the process, indoor environmental quality and patient comfort were maximized, allowing the owner to provide a healthy and healing environment. ■