Keeping Up with the High Tech Age:

Need for New Computers Met with Upgraded Heating and Cooling Plant at John Evans Middle School

Figure 1. John Evans Middle School

John Evans Middle School was built in 1962 in the high plains of Greeley, Colorado, about 45 miles northeast of Denver. In 1998, facilities executives at Weld County School District 6 decided to pursue much-needed improvements at the school since its overall electric load —and more importantly its peak amperage draw—was approaching the limit of the installed service. Without upgrading its aging central heating and cooling plant, the school would be unable to accommodate future added load from either more students or equipment. In fact, the school administration was committed to a long-term plan of installing more computers for its students and teachers, which would add to an already fully-utilized system.

The school's existing four-pipe distribution system still relied on old, inefficient gas-fired water boilers (two 3.9 million Btu/h (1,143 kW boilers)) and a 144-ton electric centrifugal R11 chiller installed when the school was originally built. Using computer load simulation tools and verifying these against field data, engineers recalculated the heating load for the school to be 3.15 million Btu/h (923kW), a 60 percent load decrease from the old system. Additionally, the school would need a minimum of 165 refrigeration tons (RT) (577 kW) of cooling capacity. Because the school is located in the dry high plains at an altitude of roughly 4,815 feet, the majority of the cooling load is sensible load (air-cooling) rather than humidity reduction (latent load).

Their solution was to remove both heating boilers and the old electric chiller, and replace them with two new high-efficiency boilers and two absorption chiller-heaters. By increasing the cooling capacity to meet the added load of more classroom computers, the system also freed up limited electric service capacity for those computers.

System Technical Overview

The upgraded central heating and cooling plant at John Evans consists of two 956kW high efficiency gas-fired combustion boilers; two direct-fired, double-effect absorption chiller-heaters; a major upgrade to their controls; and several new valves, dampers, and actuators. The new plant provides all of the school's thermal (heating and cooling of air and water) needs. All electricity is purchased from the local utility. Removing the electric chiller immediately made available a 600-amp electric device, much of which has since been reallocated for additional computers in classrooms and the school's media center.

Project Overview

LOCATION
John Evans Middle School
Greeley, CO

DATE INSTALLED
1999

FACILITY
88,000 ft^2

ELECTRIC & THERMAL
- Two natural gas-fired combustion boilers totalling 956kW (3.26 MMBtu/h)
- 3.15 MMBtu/h (923 kW) heat load; 175 ton (615 kW) cooling load
- 80 RT (280 kW) and 100 RT (350 kW) direct-fired, double-effect absorption chiller-heaters

ANNUAL ENERGY SAVINGS
$4,000

ENVIRONMENTAL BENEFITS
- 1,591 lbs NO_x avoided*
- 1,682 lbs SO_2 avoided*
- 949,816 lbs CO_2 avoided*

*Avoided emissions from absorption chillers alone. Although new boilers are more efficient than the old system, kWh consumed is roughly the same due to added capacity to accommodate school growth.

UNIQUE ASPECTS
- Electricity savings made room for new school computers
- CO_2 sensors help improve IAQ

System Design

Heating Plant – To meet the 3.15 million Btu/h (923 kW) load requirement, the engineers kept a two-boiler design. Each boiler was slightly oversized to provide some redundancy should one unit unexpectedly be out of service. The heating plant includes two Weil-McLain "Series 88" 80 percent-efficient natural gas-fired forced draft combustion boilers. The total heating capacity of the plant is 3.264 million Btu (MMBtu) (956kW), providing a 115 thousand Btu (MBtu) (33 kW) buffer.

Cooling Plant – The school district chose to replace the existing chiller with 175 refrigeration-tons (RT) (612 kW) of absorption cooling at an estimated cost of $305,000. While more expensive than the other options on a per-ton basis, this option offered the most flexibility. The final chiller plant specification included two (350 kW and 280 kW) direct-fired, double-effect absorption chiller heaters. One of the design engineers' concerns was whether the existing cooling coils and chilled water distribution system were large enough to accommodate increased cooling capacity. To address this concern, the air-handling unit (AHU) fan speeds could be slightly increased, and chilled water flow rates could be increased, enabling the existing coils and piping to accommodate the upgrade.

Air-Side Systems – In addition to retrofitting the cooling and heating plant, a number of other HVAC and control system changes were made, including replacing and installing additional exhaust fans and cooling coils. A major expansion of the Direct Digital Control (DDC) system tied the chiller and boiler plant and the many AHUs into one integrated control strategy that could be monitored remotely.

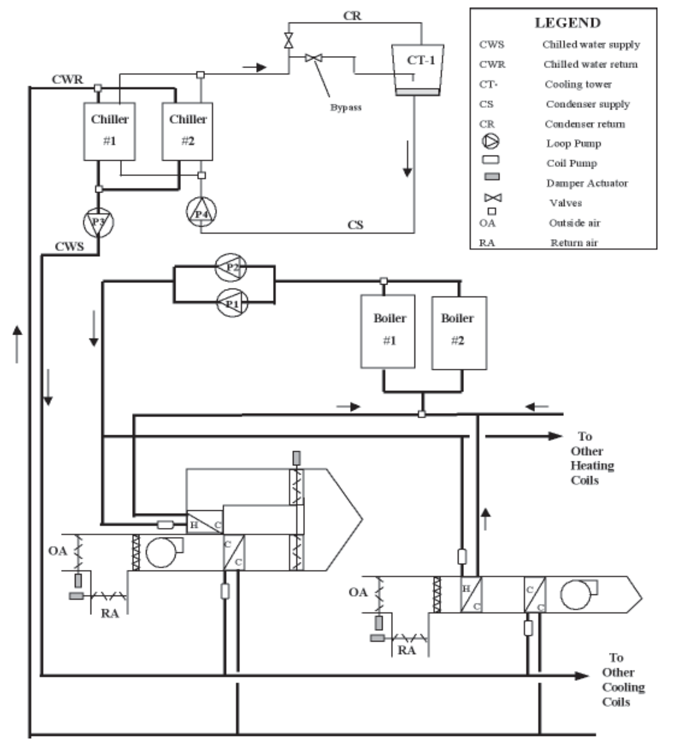


Figure 2. Schematic of central plant and air-side systems at John Evans Middle School

System Performance

In summer 1998, when the old electric chiller was still in use, consumption averaged about 70,000 kWh per month. Since the commissioning of the new system, the chiller system has efficiently met the school's cooling requirements without problems and still has capacity to spare. The absorption chillers run only an estimated 375-400 effective full-load hours each cooling season. Figures 3, 4, and 6 illustrate monthly natural gas use, actual and avoided electricity demand, and actual and avoided electricity consumption, respectively, for January 1998-October 2001.

Figure 3. Natural Gas Use at John Evans Middle School

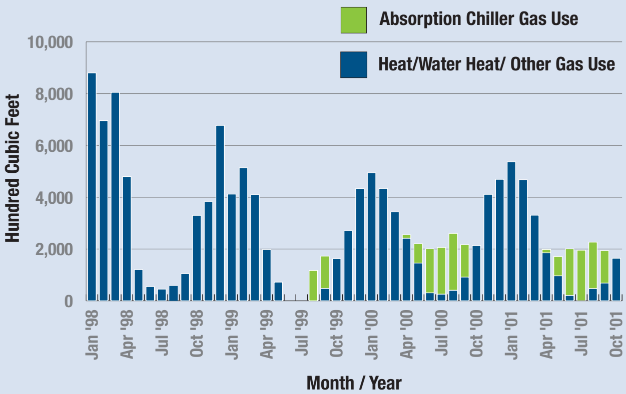
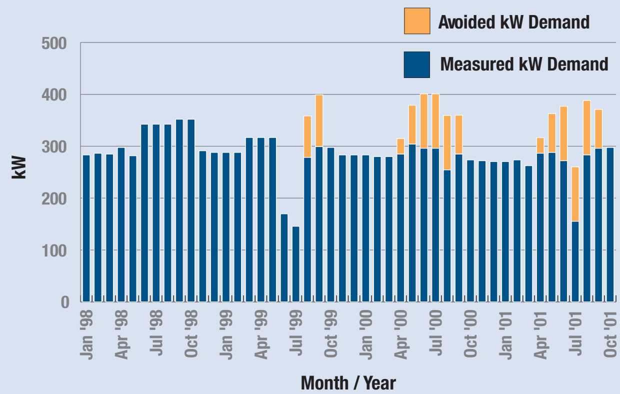


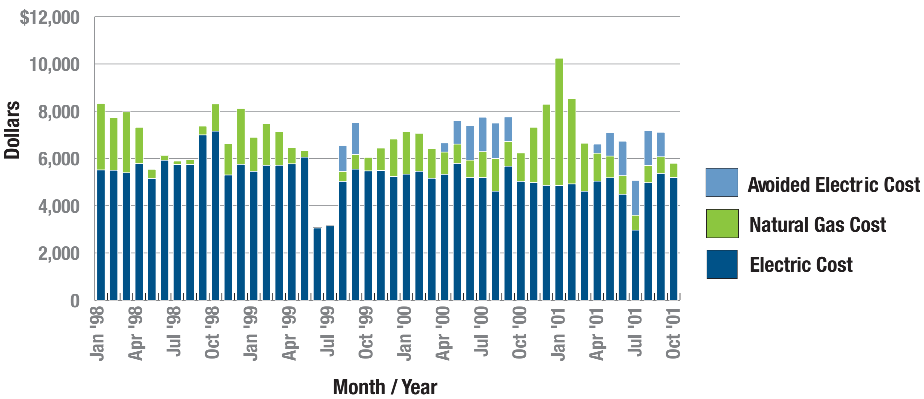
Figure 4. Actual and Projected Electricity Demand at John Evans Middle School



Financing

The retrofitted heating and cooling plant was paid for by a major bond that was secured by the Weld County School District in 1997 to improve several of its facilities.

Figure 5. Actual and Projected Energy Costs at John Evans Middle School



Economic Analysis

Often, natural gas cooling applications have a higher first-cost premium than their conventional electric counterparts. These applications are then offset by kWh and kW demand savings. In this case, the installed cost of the absorption chiller plant was significantly lower than the projected first cost of two of the four electric chiller options. Those options would have required an upgrade to electric service capacity estimated at $150,000.

The absorption chiller-heaters generate approximately $650 of kWh savings and $6,200 of kW demand savings each cooling season. The total cost of natural gas used by the absorption chillers to offset electric chiller consumption was $3,600 in the 2000 cooling season, when markets were still recovering from the winter spike, and $2,765 in the 2001 season. Net cooling savings were $3,250 for 2000 and $4,100 for 2001. This amounts to approximately 5% of the school's total yearly energy bill. Figure 5 shows monthly actual and avoided energy costs for the period January 1998-Ocotber 2001.

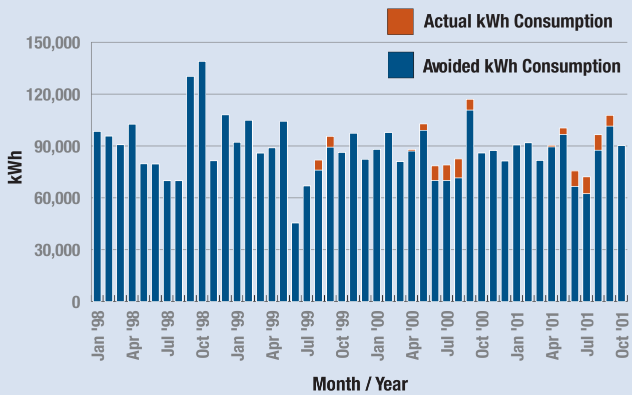
End-User Perspective

The HVAC retrofit at John Evans Middle School was completed in about eleven weeks, including decommissioning of the old heating and cooling plant, demolition and removal of old equipment, installation of new chillers, boilers, pumps, and ductwork, and wiring of the DDC system.

Oftentimes the advantages of gas cooling are disregarded because of their higher first cost and lack of understanding of the equipment. Using the gas-fired absorption chiller-heaters at John Evans Middle School, however, proved to be a cost-effective means of adding cooling capacity to meet the added load of more classroom computers, while freeing up limited electric service capacity for those computers. According to John Nail, the District Engineer for Weld County School District #6, "We were getting close to being maxed out on our electric service, so by shifting our cooling load to the gas-fired absorption chillers we were able to avoid the expense of upgrading our electric service."

The new plant has allowed the school to meet its growing information technology demand efficiently while saving money to reinvest in its students.

Figure 6. Actual and Projected Electricity Consumption at John Evans Middle School



Replicability

The Distributed Energy (DE) Program selects projects that are highly replicable, or that can be duplicated in applications with characteristics similar to DE Program-supported projects.

Replication potential can be assessed by looking at various factors of the market and the site, including:

- DE/CHP potential within market sectors and subsectors, e.g. classified by the U.S. Census Bureau's North American Industry Classification System (NAICS)
- Industry growth and drivers
- Barriers and incentives
- Load profiles, e.g., electricity and thermal energy utilization patterns
- Technical and economic feasibility of the DE/CHP system
- Capital investment payback requirements

Several market analysis and DE/CHP feasibility studies that incorporate many of these factors have been completed. The 2000 Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector study sponsored by the U.S. Department of Energy identified about 77.3 GW of combined heat and power (CHP) potential in the commercial/institutional sector. School buildings such as John Evans Middle School show about 14.9 GW of CHP potential, whereas, colleges and universities show about 4.3 GW of CHP potential.

Fifty percent of the total commercial/institutional CHP potential identified in the studies is located in nine states: California, Florida, Illinois, Michigan, New Jersey, New York, Ohio, Pennsylvania, and Texas.

Schools in the U.S. are aging—42 years old on average. The majority of these schools could benefit greatly from energy-saving improvements. Many schools are in need of major renovation, infrastructure improvements and retrofitting of physical plants. Schools are experiencing rising power and thermal demands due to growing enrollments, increased technology needs, and the trend toward year-round use of school facilities. Growing loads and competition for limited electric service capacity make schools good candidates for absorption cooling or integrated hybrid system options.

Helpful Web Sites

- Distributed Energy Program
  www.eere.energy.gov/de/
- Intermountain CHP Application Center
  www.intermountainchp.org/
- EnergySmart Schools
  www.rebuild.gov/sectors/ess
- National Clearinghouse for Educational Facilities
  www.edfacilities.org/

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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