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Reading, Writing, And BACnet®

By Jack McGowan

Alamogordo Public Schools in New Mexico has made a major financial commitment to install the largest renewable energy HVAC system in the Southwestern United States. Although geothermal (ground-coupled) heat pumps have been used for more than two decades, this project is unusual due to the comprehensive design that integrates a direct digital control (DDC) system from Delta Controls with the geothermal heat pumps and a district-wide lighting retrofit.

Alamogordo Public Schools serve a wide-ranging student community in a thriving municipality located in south central New Mexico. The district in-

cludes 15 schools, with three serving Holloman Air Force Base, home to the Stealth Fighter Wing, and White Sands Missile Range.

This project focused on the district's desire to optimize the learning environment through effective temperature control. However, they wanted more. Dave Flood, Alamogordo director of operations, and superintendent Phil Knight, Ph.D, focused this project on the high school due to critical issues at the facility. The high school was constructed in phases, and there were six different mechanical systems with corresponding control technology. The district also wanted to look at improving the lighting systems.

An energy service company evaluated the high school and was given the liberty to evaluate other schools in the district. The goal was to upgrade the high school to one standardized system for both mechanical equipment and controls. Flood and Knight had researched a great deal, but the budget would not support their project vision. The ESCO was asked to conduct an energy engineering study to evaluate controls and the earth heat exchanger required for the heat pump system. The firm was asked to complete turnkey project implementation and assembled a team including a company that had expertise in earth heat exchanger technology. Jim Coupland, P.E., Life Member ASHRAE, was hired by the district to act as the owner's engineer.

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The design firm completed a district-wide lighting survey and identified cost-effective retrofits for 13 schools. During the district engineering analysis, it became clear that DDC was needed in three schools to address high energy costs and comfort issues. These schools had been retrofitted from evaporative to mechanical cooling that was running continuously year-round. As a result, a master plan was developed outlining an \$8 million retrofit including:

- DDC in three schools,
- Geothermal heat pumps with DDC at the Alamogordo high school, and
- Lighting retrofits in the 13 schools.

The geothermal system incorporates traditional water-source heat pumps. Key changes to the units are larger condensers to accommodate wider temperature swings on the ground loop and higher efficiency compressors.

The critical component is the earth heat exchanger that consists of a series of piping loops with boreholes buried underground. A borehole is drilled, and a polyethylene piping-loop is inserted and grouted to develop thermal conductivity with the earth. The ground loops are interconnected between boreholes using a reverse-return piping scheme.

The system efficiency is further enhanced with makeup units using air-to-air energy recovery. These energy recovery units use heat wheel technology and a sequence of operation, which enables unit operation based upon carbon dioxide (CO₂) and occupancy.

Finally, this project provided a heat pump with DDC in each classroom. The first project phase encompassing 400 tons (1407 kW) of cooling was completed in Summer 2004, and the next phase will begin in Spring 2005.

Lighting upgrades are an effective way to reduce operating costs. Operations dollars are also saved because a group relamp addresses lighting in all schools at one time. This retrofit upgraded T12 lamps and magnetic ballasts to T8 lamps with electronic ballast technology.

A Delta Controls DDC system using BACnet[®] was designed to optimize daily and annual schedules, and to ensure comfortable learning environments during normal school hours. The system also provides knowledge tools necessary to perform savings measurement and verification.

Controls were implemented in all four schools, along with submeters on major electrical loads, to measure energy consumption after the project and to verify savings.

BACnet will afford Alamogordo Public Schools maximum flexibility and cost-effectiveness because in the future control products from other manufacturers can be integrated into a single, uniform system.

At Alamogordo, building-wide control was achieved through application of the manufacturer's systems at each heat pump, as well as at energy recovery makeup air units and on the earth heat exchanger ground loop. The system controls the ground loop for maximum efficiency based upon demand, flow and energy consumption. As noted, this project uses reverse-return piping, but approaches may vary. Variable frequency drives on main loop pumps are controlled by a direct digital controller for optimum performance with sequences that monitor entering and leaving water temperature on the loops, as well as load throughout the building.

The energy recovery units, designed to efficiently meet ventilation requirements for classrooms, are controlled by

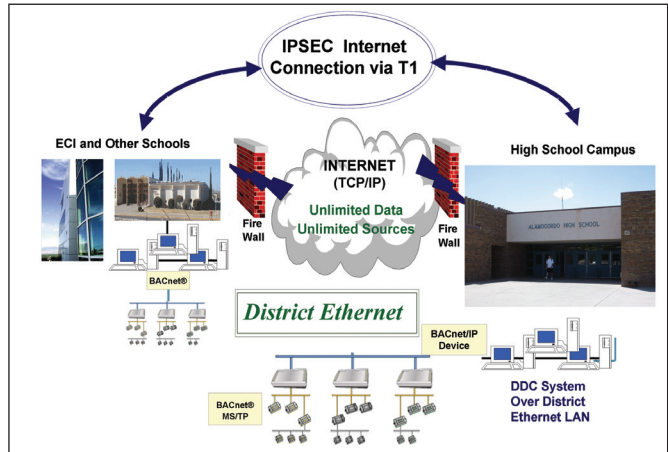
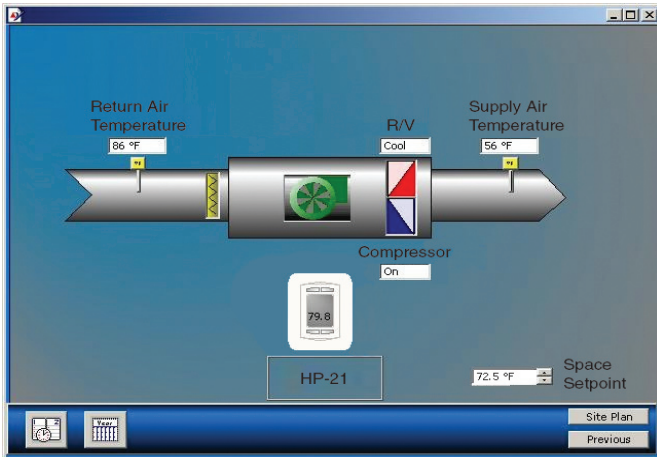


Figure 1 (left): ORCAview graphic of a classroom heat pump with direct digital controls. Figure 2 (right): System architecture integrates BACnet with District Ethernet LAN and the Internet.

BACnet controllers, based on time-of-day and air quality from CO₂ monitors. The heart of this system is the classroom, and individual heat pumps have DDC devices. Unit sequences control each stage of cooling along with reversing valve and fan start/stop. They also monitor classroom space temperature and discharge air from the unit, plus a number of alarm points to allow quick response to problems.

Another benefit of this system is that a local BACstat allows teachers to change temperature setpoints in the classroom with a 4°F (2°C) dead band. Teachers appreciate being able to control their own space. They can see the room temperature and have after-hours override from this device. If teachers work late or come in Saturday, they don't have to search for a maintenance person to turn on the heat; they just push a button.

This system offers the power of BACnet and ORCAview, a software operating package combining a graphical user interface with facility management capabilities. The software includes an object-oriented system navigation and operation tool, and provides a graphics editor for creating customized system graphics, such as those shown in Figure 1.

This tool provides monitoring and control of functions for the Alamogordo system and protects against unauthorized access. The software communicates using BACnet data structures and communication services for the manufacturer and third-party BACnet products. Alamogordo Public Schools also uses BACnet/IP to communicate over the Internet, and the district local area network can connect to any of the four schools.

The data communication architecture for this system uses extensive integration of Information Technology (IT). Figure 2 illustrates the critical elements of this system. BACnet is the standard used for DDC communication and the system interfaces directly to the district Ethernet local area network and BACnet/IP.

Systems at each school have "public Internet Protocol (IP)" addresses, and a "key exchange based IP security" technol-

ogy is used for interface. This Internet protocol security or IPSEC technology ensures secure interface with the BACnet system via the Internet. Similar terms used in the industry to describe this type of secure Internet-based communication are IP tunnel or VPN (virtual private network).

The key is that this technology provides a Web services based secure interchange using XML (eXtensible markup language) data interchanges. Integrating multiple systems via XML is an effective way to provide the district with an optimal software management tool. This means that secure system communication is available anytime, anywhere over the Internet.

District personnel can view the DDC system and also offer other features for facility management. Figure 3 shows an enterprise dashboard that provides a homepage for the school and acts as a portal to manage building systems. From this Internet portal, the district can obtain access to all building systems, as well as monitor utility costs for measurement and verification. The district also can contact the design firm by e-mail to request maintenance work. A service technician will visit the site and update the service database when work is complete. The customer can visit the site later in the day, and get the status on that day's request and all outstanding service requests.

For public schools, financing is always a challenge. This project was no exception. Traditionally, public schools have relied on a single source of funding, such as a bond or state appropriation, to make projects possible. However, school districts are approaching their debt capacities and are also finding that there are limited funds available from the traditional sources.

The Alamogordo project is a good example of how funding creativity is being used, as the funds to complete the project included:

- \$1 million in state funding,
- \$1.98 million in performance contracting, and

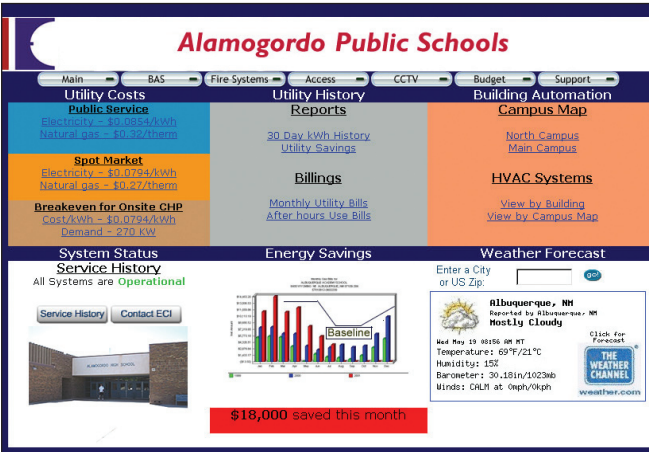


Figure 3: An enterprise dashboard acts as an Internet portal using BACnet/IP.

- \$5 million in general obligation bonds and property tax from the mil levy.

The design firm developed and facilitated the performance contract, including the financing, which was ultimately provided by La Salle National Bank via a 10-year, tax-exempt municipal lease purchase. This is clearly a bellwether trend for public sector funding. In the future, combining multiple funding sources will become a requirement rather than a novelty.

Alamogordo Public Schools is committed to achieving the highest levels of efficiency and effectiveness and the lowest impact on the environment from their operations. Through this comprehensive project, the district has taken a strategic approach to energy and environmental management with some impressive results.

The initial phase of the project implemented \$2.4 million in major projects and has generated annual savings of 1,245,472 kWh of electricity in a service territory, with a blended cost per kilowatt-hour of \$0.14.

The environmental benefit of that electrical savings from avoided power plant emissions is 19,928 lb (9040 kg) of sulfur dioxide (SO₂) and 184,330 lb (83 612 kg) of CO₂. By eliminating evaporative cooling in parts of the high school, the new heating and cooling system will also save more than 4 million gallons (15 million liters) of water per year.

From the creative financing mechanisms that were necessary to make the project possible to effective DDC for the geothermal technology, this project is unique. The manufacturer was key to the success of the project and will continue to ensure that the district achieves the energy and cost savings necessary to service the debt, while optimizing the learning environment.

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