NETWORKED BUILDING CONTROL ENHANCES DEMAND RESPONSIVENESS

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The proliferation of the Internet and information technology (IT) hasn't stopped at the outside of buildings—it's actually changing the way that buildings are operated. Facility managers and energy service providers (ESPs) are beginning to reap the benefits of networked building control—the practice of integrating building management systems (BMSs) with corporate intranets or the Internet.

One of the main advantages of networked systems is that facility managers can control the operation of buildings scattered across a campus or across the U.S. It's no longer necessary to physically travel to numerous buildings to control equipment. And because these networked building systems are easier to use, facility managers are more likely to detect equipment problems before a total failure can occur.

In addition, the price of a networked system is often comparable to that of legacy systems, because the new system can leverage existing IT infrastructure. Although there have been concerns about security with these network-based systems in the past, industry experts assert that they are now as secure as legacy systems. IT professionals have been working closely with building managers to ensure that the new building systems have appropriate firewalls and use encrypted data.

Another benefit of networked building control is that it enables facility managers to respond to load-curtailment signals more quickly. That's good news for ESPs that need a fast response when their independent system operator (ISO) asks for load reduction. By making it possible to aggregate multiple buildings through a single system, networked building control can also result in greater occupant comfort and continuous operation during curtailments, because equipment can be cycled on and off across a large portfolio of buildings.

By encouraging customers to network their building systems, an ESP can improve its ability to control peak loads while helping customers to more effectively maintain their HVAC systems. Two organizations blazing a path in this area are the California Energy Commission (CEC) and the New York State Energy Research and Development Authority (NYSERDA). Both organizations are providing education and technical assistance to constituents interested in network-based building management. Many of the facilities that have joined such programs have achieved cost-effective demand reductions.

What Is Networked Building Control?

There are two types of products available for network-based building management—BMSs made accessible over the Internet or through a local area network (LAN) and add-on Web-based systems.

Building Management Systems

Systems designed to monitor, manage, and control building equipment go by many names: building automation systems (BASs), energy management systems (EMSs), energy management and control systems (EMCSs), central control and monitoring systems (CCMSs), facilities management systems (FMSs), and so on. Throughout this paper, we'll use building management systems (BMSs) as an umbrella term.

A BMS is an integral part of facility management. Although they are most prevalent in large buildings, BMSs are available for structures of most sizes. They control the operation of HVAC equipment (when that equipment starts and stops) as well as its running capacity, adjusting fan speed and supply air temperature to maintain comfortable conditions while optimizing energy use. Many BMSs also control fire response systems, security for access and control, video surveillance systems, and lighting systems.

Traditionally, BMSs have been capable of saving about 10 percent of overall building energy consumption[1] by making sure that equipment runs only when necessary, that it operates at the minimum required capacity, and that peak electric demand is minimized. BMSs may also help save energy by recording equipment operation data that can be used for diagnostics and troubleshooting.

BMSs consist of sensors, controllers, actuators, and software. Sensors measure environmental conditions such as temperatures, pressures, on/off status, and electrical current and send that information to microprocessor controllers. The controllers process the sensor inputs and generate outputs that are passed along to devices or equipment. The outputs often cause equipment operation to be modified. For example, the outputs may cause fans to speed up, dampers to close, or equipment to turn on.

A BMS may control outputs directly or it might communicate with specialized controllers built into equipment such as boilers and chillers, telling those components how to adjust the operation of the equipment. It is possible for the controllers in a BMS to also communicate with each other to coordinate systemwide management strategies. For that to happen, the controllers must share a common communications protocol—that is, software containing a set of rules or standards that govern the exchange of data between control units and issue commands to equipment over the digital communications network.

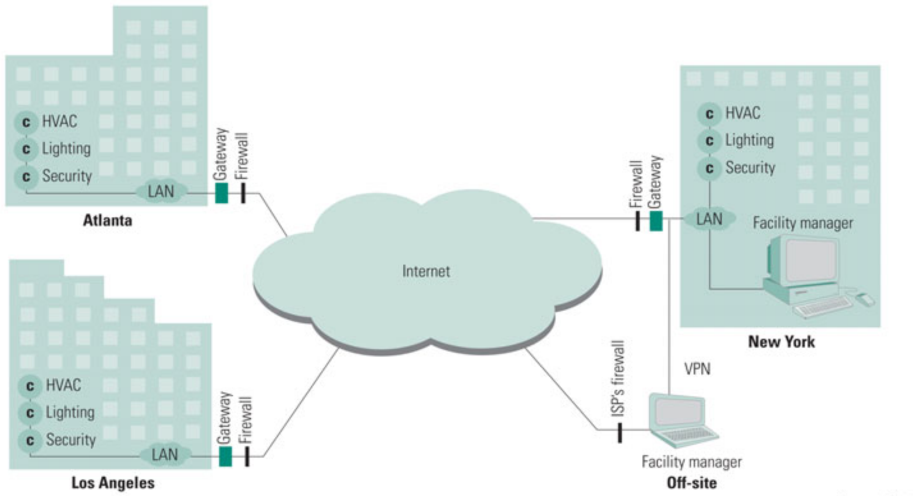
Some protocols are proprietary to a specific manufacturer. Proprietary protocols require the user to purchase all controllers from the same vendor or to buy expensive translating devices called gateways to communicate with other equipment. Newer open protocols include BACnet™ (Building Automation Control Network) and LonTalk™. Developed by ASHRAE (the American Society of Heating, Refrigeration, and Air-Conditioning Engineers), BACnet was created to provide a standard protocol that all manufacturers could use. Echelon Corp. developed LonTalk for similar reasons, although LonTalk requires that a proprietary chip be embedded in all control devices used in a LonWorks network.

No matter which protocol is used, controllers communicate with a central computer, where the front-end software resides. This is where the "network" in networked building control comes in. The building manager can pull up the interface via the Internet or LAN to control the end-use technologies or access data via the Web (**Figure 1**).

[1] David Wortman, Evan A. Evans, Fred Porter, and Ann M. Hatcher, "An Innovative Approach to Impact Evaluation of Energy Management System Incentive Programs," *Proceedings, American Council for an Energy-Efficient Economy Summer Study* (August 1996), pp. 6.163–171.

Figure 1: How networked building control works

Controllers embedded in lighting, HVAC, and security equipment communicate with each other via a local area network. Each building is then connected to the Internet through a gateway that is protected by a security firewall. Because these networked building systems offer remote control capabilities, facility managers can monitor and control their buildings from any location with a Web connection. They can also manage multiple sites simultaneously or aggregate them for load control.



Source: Platts

Add-on Enterprise Management Systems

The long reach of the Internet has also given rise to a new class of products—add-on enterprise energy management systems. These systems are typically used to manage multiple sites at the same time, to access building information from the Web, or for load curtailment. Vendors of such products include WebGen Systems, CMS Viron, Tridium, Enflex, Evenergy, Silicon Energy, Pentech, Cimetrics, and others. Add-on systems are different from BMSs, because they are designed to be integrated with an existing system that is unable to perform the specific network-based functions we've been describing. A full-scale BMS has those capabilities built in.

An example of an add-on enterprise system is CMS Viron's CurtailmentVision—it's a Web-enabled, integrated metering and control technology that allows for centralized remote control of loads, as well as for immediate access to incremental meter data.

CurtailmentVision was installed in the Foothill–De Anza Community College campus as part of an upgrade that included expanding the capabilities of the existing control system and linking both the controls and the utility meters to the Internet. CMS Viron installed a panel at each campus that contained a controller, a gateway that connected the campus LAN to the Internet, and two relays. When a building operator sends a curtailment signal via the Web, it travels through the gateway to the controller and ultimately on to one of the relays. When a relay closes, a digital signal is sent to the BMS, which in turn, sends digital signals to hundreds of HVAC control modules. In this case, each relay corresponds to a curtailment level. For example, if a level-1 curtailment signal is received, the BMS would raise temperature setpoints by four degrees in every campus zone. If a level-2 curtailment signal came in, the BMS would shut down the entire HVAC system.

The gateway is also wired directly to a pulse initiator on the electrical meter, which sends kilowatt (kW) data from the meter to the gateway every 15 minutes. The gateway sends that data across the Internet to a database that resides on a CMS Viron Web server. This allows building operators to schedule or initiate curtailments up to 1.7 megawatts (MW) and to view instantaneous and historical demand data from a password-protected Web site (www.utilityvision.com) that is accessible from any computer equipped with a standard Web browser and Internet access.[2]

These add-on systems can also incorporate other Web services—tying in with other computer systems available online or on the LAN. For example, WebGen Systems, a provider of add-on systems, sells a product called Intelligent Use of Energy (IUE) that works over the Internet to automatically make the best use of energy on a day-to-day basis and to deliver automated curtailment when needed. Because IUE is hooked into the Internet, WebGen is able to pull weather feeds from the National Oceanic and Atmospheric Administration, giving the system the information it needs to forecast building energy needs six to eight hours in advance. This prevents running into a situation, for example, in which an unexpected cold front moves through town at 2:00 p.m., and the local university's building manager has to run around manually turning on the heat in every building on campus.

IUE also ties into pricing feeds from the ISO and utilities, making it possible to initiate automatic curtailments if prices spike. IUE is currently installed in 200 buildings, and WebGen says it will be installing 300 more systems this year.[3]

Why Networked Building Control Is Better for Demand-Response Programs

The convergence of IT and building systems technology has produced secure, cost-competitive products that are more effective for demand response than non-networked control for several reasons. Networked building control enables cost-effective load control, faster response to curtailment requests, the ability to aggregate buildings, and, as an added benefit, makes it possible for ESPs to check their customers' energy usage.

It's cost-effective. To determine whether a technology is feasible for load control, we typically compare it with the cost of new generation. If it costs about $400/kW for a new gas turbine, then any technology that costs significantly less than $400/kW could be considered cost-effective. We can't place an exact price per kilowatt on networked building control because each installation is so location-specific, but we have evaluated the economics of several projects and it seems as though networked building control is cost-effective for load control (**Table 1**).

Table 1: Cost-effectiveness of networked building control for demand response

The California Energy Commission runs its Enhanced Automation program to provide information and technical assistance to facilities wishing to upgrade their building management systems (BMSs). The goal of the program is to enable facility managers to better control energy costs and to respond to price signals while maintaining the comfort and productivity of building occupants. All of the installations implemented under this program have proved to be cost-effective.

Project	Project Cost ($)	Curtailable demand (MW)	Cost per kW ($)
Alameda County	280,000	1.4	200
Staples	320,000	2.8	114
Hewlett-Packard	275,000	1.5	183
Foothill-De Anza Community College	283,140	1.7	166
Lafarge	273,333	22.0	12

[2] California Energy Commission, "Enhanced Automation Case Study 4," from www.consumerenergycenter.com/enhancedautomation (accessed May 5, 2003).

[3] Paul O'Conor, personal communication (March 3, 2003), Chief Marketing Officer, WebGen Systems, Cambridge, Massachusetts, tel 617-349-0724 ext 120, e-mail poconor@webgensystems.com.

It enables a faster response. The remote control capabilities provided by networked building control make it possible for facility managers to respond to curtailment signals more quickly than they can with non-networked systems. With older stand-alone systems, a facility manager has to run around and manually shut off equipment in response to a curtailment request. If that manager is responsible for buildings spread out over a large campus, or even across the country, that task could take hours. And if the facility manager happens to be away from his office and the dedicated system workstation, his company wouldn't be able to respond to curtailment signals at all. With the remote control capabilities inherent in networked building control, facility managers can respond quickly and easily, no matter where they—or their buildings—are.

For example, Roche Bioscience, a medical research firm in Palo Alto, California, has a 760,000-square-foot campus. Under a grant from CEC, Roche installed a Web-based add-on system that gave facility managers the ability to change setpoints, adjust schedules, and manipulate equipment from anywhere on the company's large campus. Roche facilities operators can log onto the Internet to monitor and control buildings, and they can dispatch load from any building on the campus.

In order to obtain the CEC grant, Roche had to demonstrate that it would be able to achieve a demand reduction of 10 percent—in this case about 1.5 MW—within 30 minutes of an ISO request. Given the size of the Roche campus, had the facility managers needed to physically go to each building to adjust load, the company would not have been able to meet that goal. But with the network-based control system, a job that would have taken several hours took only a matter of minutes to complete.[4]

Multiple facilities can be aggregated. Web-based building management allows multiple buildings to be controlled from a single location. This functionality is extremely valuable to university campuses or office parks as well as to chain stores or national accounts with facilities in different places. Large corporations using networked building control are able to reduce load in response to requests from utilities and other energy agencies more effectively than if load for each individual store had to be adjusted. Aggregation was not possible in the past because the cost of running phone lines to each facility would have been cost-prohibitive; network-based control offers a cost-effective alternative.

For example, Tim Speller, corporate energy manager for PETCO, told us that after installing network-based systems at 127 stores nationwide, he can now curtail load at any location with only a few keystrokes. PETCO was able to curtail an average of 5.3 MW during the test period (May through November 2002).[5] Speller said that he wouldn't have been able to pull that off in the past, because a system that relied on dedicated phone lines—about the only option at the time—was simply too costly to consider. He didn't run the exact numbers, but his rough estimates indicated that it would have been nearly impossible to cost-justify.[6]

Home Depot provides another example of successful aggregated curtailment using network-based controls. Home Depot outfitted 36 stores in New York State with BMSs linked to a new intranet-based communications system. As a result, when the New York ISO asked for curtailment, the company was able to deliver an average reduction of 130 kW per store, for a total reduction of 4.4 MW. And best of all, the adjustments were made from Home Depot's central operations center in Atlanta, which oversees dispatch. These 36 stores can be controlled in groups, an approach that is faster and more reliable than

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[4] Tridium Case Study from www.tridium.com (accessed May 3, 2003).

[5] ICF Consulting, "Small Commercial and Industrial HVAC and Lighting Demand Response Program: Draft Pilot Test Report for PETCO Animal Supplies Inc." (January 21, 2003), Sherman Oaks, California.

[6] Tim Speller, personal communication (May 21, 2003), National Energy Manager, PETCO, San Diego, California, tel 858-909-4681, e-mail tims@petco.com.

controlling each store on a separate computer screen via dial-up connections, or relying on the facility manager at each store to manually turn off loads.[7]

Another benefit of aggregation is that load reductions aren't as noticeable to occupants. That's because the networked system can rotate the cycling of equipment across a large number of buildings. This helps to maintain occupant comfort and to keep processes running during load curtailment.

Hewlett-Packard (HP) recently installed a sophisticated intranet-based controls system at its Roseville, California, campus. The new system allows HP to control 10 buildings totaling 1.4 million square feet from a single location. Before, HP had to shut down equipment and entire processes in response to curtailment requests. But with the networked system, the company is able to curtail load without shutting down equipment, disrupting processes, or sending people home.[8]

Utilities can also receive data. Networked building control can allow utilities to monitor their customers' energy usage to prepare for peaks. For example, a utility could pull up a facility or campus Web site, and use a monitoring-only password to look at energy-related information for that facility. In the absence of a Web-based system, the utility could only access this information by sending someone to the facility or asking the customer for a printed report.

Access to this type of information is also useful for ESP load management activities. Before the utility sends out a curtailment signal, it could check to see how much load is online. Or after a signal has been sent out, utility personnel could check to see how much load is actually being reduced. We're not aware of any utilities that are using customers' networked building management systems this way at present, but we expect that there will be some early adopters before long.

Because networking building controls is cost-effective for demand response and enables faster response to curtailment signals, it would seem that ESPs with demand response programs could benefit by encouraging their customers to adopt this technology. The facility managers probably won't mind the temporary disruption of having such a system installed, because networked controls will help them maintain occupant comfort and continue operations during curtailments.

ESPs Take the Reins

ESPs can promote the use of networked building control by offering technical assistance, educating customers about the benefits of these systems, and by encouraging customers to take advantage of funds that may be available from such entities as CEC and NYSERDA.

CEC started its Enhanced Automation program in response to California's supply shortages. The commission provides information and technical assistance to facilities wishing to upgrade their BMSs. In the short term, the program is aimed at promoting automation technologies that will enable facilities to respond more effectively to curtailment signals—for example, by turning off most lights for immediate demand response. In the long-term, CEC hopes that enhancing customers' BMSs will reduce their overall energy use. So far, CEC has provided technical assistance to 10 facilities that have implemented Internet-based BMSs; it plans to provide support for implementing such systems at up to 350 facilities.

[7] Mark Breuker, personal communication (March 20, 2003), Account Executive, Prenova, Atlanta, Georgia, tel 678-581-8111, e-mail mbreuker@prenova.com.

[8] California Energy Commission [2].

All of the facilities showcased in CEC's case studies use network-based controls to monitor and control HVAC; some of the installations also monitor and control lighting systems.[9] For more information on CEC's Enhanced Automation program, visit www.consumerenergycenter.com/enhancedautomation.

In New York State, NYSERDA isn't recommending any specific technologies because it wants to remain technology- and vendor-neutral, but it does offer technical assistance to facilities that wish to upgrade existing BMSs. NYSERDA will pay half the cost of having engineers go to a facility and do an audit, but the organization doesn't install any technologies. Under the auspices of its load control programs, NYSERDA provides incentives for upgrading BMSs as long as the upgrade is made in conjunction with load control. For example, in return for NYSERDA's help in upgrading its system, Lafarge Building Materials is now able to shed up to 22 MW upon request.[10]

So far as we know, there aren't any local utilities offering technical assistance for networked building control, but we expect several ESPs to take advantage of this opportunity for improving load control in the near future.

What Will the Future Hold?

Despite the advantages of networked building controls, BMSs still lack the means to communicate with each other and with other business systems unless they're designed to speak exactly the same language. In the near future, we expect more building control systems will be based on Extensible Markup Language (XML), which is used for Internet programming. Using XML will help integrate building systems with each other and with other business systems, and it will enable the businesses that manage buildings to run more efficiently.

Microsoft and other IT companies designed XML to deliver structured content over the Web, and it's becoming the IT industry standard for data exchange. XML will ultimately replace Hypertext Markup Language (HTML), which is well-suited for displaying information but does not provide the structure necessary to organize and exchange data. HTML works fine for a typical Web interaction: a human using a browser to request a page from a Web server. But XML allows machines and business systems to communicate with each other, because data can be automatically requested from another system. For example, XML is what connects an airline's reservation system with that of a rental car agency's system so that people wishing to make travel plans can do it all in one place. XML-based controls will enable building systems to communicate with each other in a similar manner.

Another benefit of XML-based control systems is that they can tie into external information systems that speak XML anywhere in the world. This should be especially attractive to utilities that employ real-time pricing, because building managers could automate their utility procurement based on pricing.

XML-based controls could further enhance demand responsiveness, as well. With the exception of a few online services like Apogee's Demand Exchange, utilities resort to using fax, e-mail, or telephone to notify end users of a curtailment event. With XML-based controls, the utility's load management system could speak directly to a facility's BMS to automatically initiate and perform curtailments without the involvement of a building operator.

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[9] Julia Larkin, personal communication (February 7 and May 22, 2003), Project Manager, Kema Xenergy, Oakland, California, tel 510-891-0446 ext 4120, e-mail jlarkin@kema-xenergy.com.

[10] Chris Smith, personal communication (February 18, 2003), Associate Program Manager, Energy-Efficiency Services, New York State Energy Research and Development Authority, Albany, New York, tel 518-862-1090 ext 3360, e-mail cjs@nyserda.org.

Vendors, Internet associations, and research agencies are actively trying to incorporate XML with building controls. We don't expect XML to replace BACnet or LonTalk in the near term, but it is a possibility for the future. Before that can happen, XML guidelines need to be established.

Lawrence Berkeley National Lab (LBNL) is also spearheading a project to demonstrate the potential of XML-based controls. As part of the California Energy Commission's Public Interest Energy Research Program for High-Performance Commercial Building Systems, a research team led by Mary Ann Piette is conducting case studies and demonstrations to evaluate state-of-the-art demand response technologies. LBNL plans to send XML-based price signals to several facilities with XML-based controls to initiate an automated load reduction. The researchers will collect data on how the systems respond to that signal and evaluate response performance late in 2003.[11]

Conclusion

The building controls industry is transforming at a rapid pace, and there are more changes to come. All these improvements are likely to make facility managers' jobs easier and businesses more efficient. Changes in the building controls industry should also yield cost-effective demand response with more occupant comfort and continuous operations. In the future, we will likely see XML-based controls, which will further enhance demand responsiveness.

[11] Mary Ann Piette, personal communication (July 30, 2003), Deputy Group Leader, Commercial Building Systems Group, Lawrence Berkeley National Laboratory, Berkeley, California, tel 510-486-6286, e-mail mapiette@lbl.gov.