Automated Demand Response Cuts Commercial Building Energy Use and Peak Demand

The Problem

Commercial buildings are major drivers of peak electric demand, particularly in summer. If peak demand exceeds available supply on hot days, brownouts and blackouts can occur throughout a region. Utilities keep electric generators on-line throughout the year just to meet high demand during peak hours—a solution that wastes energy and increases air pollution. Demand-response tariffs and programs help to reduce peak loads by temporarily reducing electricity use. The efficacy and acceptance of demand-response programs have historically been limited by their dependence on human intervention, a limited understanding of building controls, and a lack of appropriate communication technology.

The Solution

Automated demand-response (AutoDR) systems use Internet-based electricity pricing and demand-response signals to initiate preprogrammed control strategies that provide fully automated management of building energy use. When electricity prices are high or when the grid is nearing full capacity, these control strategies reduce (or "shed") electric loads. In this way, AutoDR increases the reliability of the electric grid while reducing the need to use backup electric generators or to build new power plants.

Since 2003, researchers at the Lawrence Berkeley National Laboratory (LBNL) have been conducting field tests through the Public Interest Energy Resesarch Demand-Response Research Center to develop the ability of AutoDR to alert large commercial buildings about demand-response signals. The tests have helped researchers to understand which demand-response strategies can be effectively automated and to determine the feasibility of sending common signals to large facilities. Tests were conducted in a variety of sites, including office buildings, post offices, museums, and high schools. Throughout five years of testing, various types of communication technology were integrated into each site's energy-management and control system (EMCS). Results of the tests show that AutoDR-enabled buildings can achieve an average peak demand reduction of 10 to 14 percent (**Table 1**).

Features and Benefits

After a facility manager defines a demand-response strategy for a building, AutoDR comes into play. It features a communication-system design based on a client-server infrastructure (**Figure 1**). This infrastructure links a building's existing EMCS and related control systems to an Internet signal. In operation, peak-event signals are defined by a utility (Item 1 in Figure 1) and sent to a demand-response automation server (DRAS, Item 2). A client, such as an Internet relay or other web-service software (Item 3), polls the event information every minute. The client signals the EMCS (Item 4) to trigger the end-use load strategy (Item 5), which is commonly targeted to space conditioning or lighting systems. In the case of a demand-response signal, the preprogrammed strategies are carried out. This system also allows facility managers to opt out during periods when they find demand-response strategies to be unacceptable.

Table 1: Average demand reduction

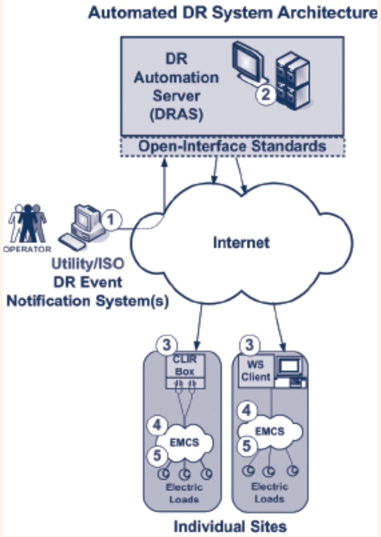
Field tests showed that automated demand-response systems reduced the average whole building peak electricity demand by up to 14 percent.

Research year	Client software	Average demand reduction (%)
2003	Web services (WS) XML only	10
2004	Internet relay and WS	14
2005	Client and Logic with Integrated Relay (CLIR) and WS	13
2006	CLIR and WS	14

Notes: XML = a language used to communicate data across different information systems.

Figure 1: Automated demand-response infrastructure

Automated demand response (DR) uses a client-server architecture.



Notes: CLIR = Client and Logic with Integrated Relay; EMCS = energy management and control system; ISO = independent system operator; WS = web services.

AutoDR is widely applicable, with systems now in use in more than 100 commercial facilities. The systems can be implemented in a variety of ways, allowing large loads to be shed without occupant complaints. The project came to the following conclusions.

Most building controls and communication technologies are capable of DR automation. The DR automation server infrastructure is designed in such a way that any building with an EMCS and an Internet connection can participate in AutoDR. A variety of connections, such as the Internet relay, Internet gateway, and the Client & Logic with Integrated Relay (CLIR) box, provide solutions that each site can employ (or use).

A variety of shedding strategies can be effective. Depending on the type of equipment and control system at each site, a variety of HVAC and lighting load-shed strategies were developed. For example, researchers found *global-zone temperature setpoint adjustment* to be the ideal DR strategy for HVAC systems with direct digital controls. The term refers to the practice of increasing the cooling setpoint and decreasing the heating setpoint, thereby relaxing the lower and upper limits of the setpoint deadband. The acceptability of setpoint adjustment strategy depends on how much, how fast, and how often it is executed, as well as other occupant-related issues such as occupants' preparation and the information provided to them.

Large loads can be shed without complaints from occupants. On September 8, 2004, the total demand savings—achieved through space-conditioning and lighting-shedding strategies—from five AutoDR sites reached 1 megawatt (MW). There were no complaints from any of the occupants in any of these buildings. More recent, fully automated load-shedding strategies have reached over 2 MW. Over 25 MW of load were being equipped with AutoDR technologies in 2007.

Applications

Large commercial buildings (those with electrical loads over 200 kilowatts) with an EMCS and process-heavy industrial facilities with centralized controls are ideal customers for AutoDR because of their heavy energy needs, their ability to shift energy use, and their potential for DR-strategy implementation.

California Codes and Standards

As a result of the field tests conducted by LBNL, an energy-management system strategy to reset the building to a higher temperature—known as global setpoint adjustment capability—was included in the 2008 California Energy Standard (Title 24).

In the future, communications and signaling standards, as well as codes that require demand response as a low-power mode of operation within the EMCS, should be established.

What's Next

Researchers have begun to examine which demand-response strategies can be automated in industrial facilities. Additionally, work is underway on a tool that can help determine what strategies and peak savings are feasible for an existing facility.

LBNL is also working with an industry technical advisory group to make the demand-response automation systems into an open communication standard using the client-server architecture.

Collaborators

Organizations involved in this project include Pacific Gas and Electric Company (PG&E), Southern California Edison, San Diego Gas & Electric Company, Global Energy Partners, and Akuacom.

For More Information

For more information on this project, please contact the California Energy Commission researcher listed below. The SCE and PG&E AutoDR website is at www.auto-dr.com.

More PIER Technical Briefs can be found at www.energy.ca.gov/research/techbriefs.html.

Contacts

California Energy Commission, Michael Seaman, mseaman@energy.state.ca.us, www.energy.ca.gov/pier/buildings

Lawrence Berkeley National Laboratory, Mary Ann Piette, mapiette@lbl.gov, 510-486-6286

About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) Program. PIER supports public interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

Arnold Schwarzenegger, *Governor*

For more information see www.energy.ca.gov/research

California Energy Commission

Chairman: Jackalyne Pfannenstiel *Vice Chair:* James D. Boyd
Commissioners: Arthur H. Rosenfeld, Jeffrey Byron, Karen Douglas

PUBLIC INTEREST ENERGY RESEARCH "Research Powers the Future"

CEC-500-2008-086-FS
November 2008