DEMAND RESPONSE for Small to Midsize Business Customers

Reference Guide

CEATI INTERNATIONAL

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1 OVERVIEW

Demand Response (DR) programs provide commercial and industrial (C&I) business customers with payments or favorable rates so that those customers will reduce their energy demand at peak times (when energy is very expensive), when the power system is setting a peak, or when there is a reliability risk to the grid. You may be a good candidate for demand response if your business has:

- Operational flexibility (the ability to delay production to another period of the day or week, or to switch a load off temporarily),
- Fuel switching, energy storage, on-site generation, or production storage options, or
- An energy-management system or building automation system (BAS) that controls significant portions of lighting, HVAC, or process equipment.

There are many factors to consider when you are deciding whether a DR program is right for your facility, from incentive amounts to length of expected curtailments. Each program offers slightly different policies and terms, but the underlying concept for all of them is that many small reductions in demand can create a basket of benefits for all consumers. Demand response improves the reliability of the grid, delays or eliminates the need for new generating plants, reduces the market price of power, and can lead to savings on energy and demand charges at the facility level—all while generating revenue for the participant.

This primer explains what demand response is, how businesses can benefit from participation, and various participation strategies. It explains how baselines help both the customer and the DR provider understand what a facility's energy use would have been, in order to evaluate how much load was reduced during an event. Metering technologies that help verify load reduction and determine appropriate compensation are discussed. This primer further describes how load shedding, load shifting, on-site generation, and energy storage can all be used by businesses to reduce their load during an event. It highlights how you can use a BAS to simplify and streamline your DR strategies and how generators and storage technologies can help displace your electric load. Finally, the appendix provides sector-specific recommendations on the best opportunities for DR savings.

2 WHAT IS DEMAND RESPONSE?

Many electric utilities and regional power management organizations offer **demand response** (DR) programs for their commercial and industrial (C&I) customers. Sometimes, these programs are offered by **DR providers** that are working on behalf of utilities to deepen the engagement of C&I customers in DR activities. DR programs may also be referred to as load management, load-shedding, or curtailment programs.

Demand response involves participants reducing their electrical demand by shifting their energy use to other periods of the day or week, turning off non-essential lighting, changing temperature setpoints, cycling HVAC, and taking other actions to reduce their usage at times of peak demand or peak price, or during **DR events** (the time frame in which a program requires that participants curtail energy use). Often, these types of events occur between noon and 7:00 p.m. on business days. In exchange for payments from system operators, utilities, or DR providers, businesses engage in DR activities according to time frames and notification schedules set by the system operator or utility.

In a DR event (Figure 1), the system operator signals the DR providers, who in turn contact the enrolled customers. Upon notification (a phone call, pager signal, or e-mail), these customers will curtail their electric loads based on a pre-arranged plan that makes sense for their business.

Figure 1—Basic DR event sequence

a. Why Do We Need Demand Response?

Utility loads are growing along with our population, the number of plug loads we all use (such as consumer electronics), and the use of central air conditioning. In addition, when electric vehicles become more common, their impact on energy consumption is likely to be significant.

Utilities have two primary strategies to meet this growth in demand: **Build** expensive power plants and transmission and distribution systems to provide energy on days with high peak demand, or **manage** the growth in demand for electricity.

Demand response effectively provides an additional power resource to the system operator at times when it is most needed, reducing or eliminating the need to build expensive “peaking” plants that operate only a few hours each year.

b. Demand Response and Load Management

Understanding and managing electric load is critical to participating in DR programs. Before you can manage your energy use, it is helpful to understand your **energy demand** (the sum of the various electric loads in your business at any given time) and how you are charged for that energy. Each utility charges its customers for the amount of energy they consume. In addition, C&I customers are also frequently billed for their **peak demand**—the highest rate at which the customer is using energy, generally measured in kilowatts (kW) over a one-hour period.

A load shape, such as the one shown in Figure 2, is a graphical representation of how a customer uses electricity over the course of a day. The height of the graph at any point shows the customer's peak demand; the area under the load shape is the amount of energy consumed, in kilowatt-hours (kWh), over a given time period—in this case, a 24-hour period.

When customers are billed for the amount of energy they use, they are often also billed for the magnitude of their demand—the maximum amount of electricity drawn from the grid at a single moment in time. This **demand charge** is usually based on the highest amount of demand registered during the billing period (the peak demand). Demand charges may also include "ratchet charges" that tie the demand charge to the highest level achieved in a preceding period (such as the previous six months). Because a demand ratchet can be a considerable

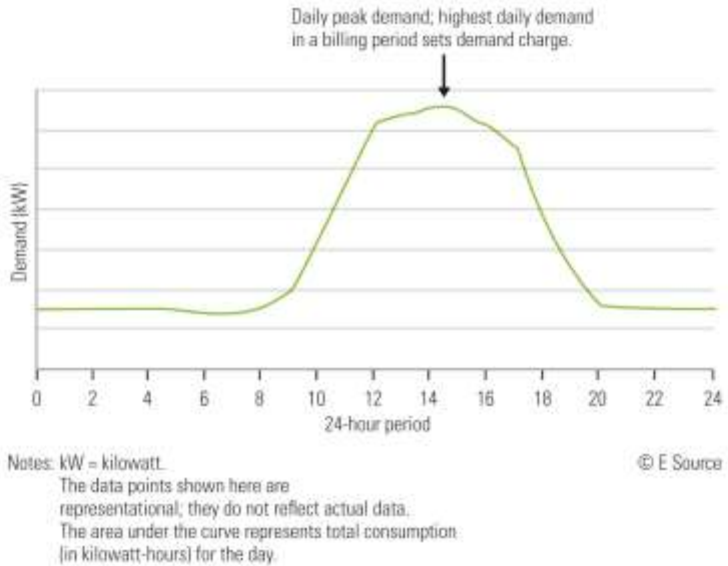

Figure 2—Hypothetical load shape showing peak demand

percentage of the bill, C&I customers should reduce peak demand whenever possible to reap the economic benefits.

Consumers who manage their facility load profiles with a view to reducing their peak demand—and therefore their demand charges—are effectively undertaking their own DR program. It is entirely possible for consumers to practice their own DR program in response to conventional rate structures while participating in system operator or utility DR programs at the same time.

3 WHY SHOULD I PARTICIPATE?

Depending on the programs offered by your system operator or utility, there may be a variety of benefits to your business for participating in demand response. Listed below are some of the most common benefits.

DR payments (cash or bill credits). Utility customers get paid to participate in DR programs. Some utilities offer a payment for enrolling as well as a payment per event. These payments might be flat rates for simple actions such as **direct load control** (in which a utility obtains permission to turn customers' air conditioners off for short periods of time during critical heat events, for instance). For more complex DR programs, the payments are often based on either the cost of the electricity that was *not* used during a high-demand period or on the reduction in overall demand. Larger payments come with more stringent requirements: Generally, programs pay more if they have shorter notification times, have more frequent and longer events, and specify guaranteed mandatory reductions.

Reduced power consumption (bill savings). You may lower your electricity bill if your DR actions lead you to use less electricity overall—either by load shedding or by turning your DR actions into overall long-term energy efficiency. By understanding how your facility's energy load fluctuates throughout the day, you may be able to reduce your peak demand and create additional savings. Also, if you are already enrolled in time-of-use rates, then DR participation may shift usage to lower-price periods.

Reduced hourly market prices for power (lower overall prices). Reducing demand during peak times minimizes utilities' need to secure energy from more expensive sources such as peaking generators or spot markets. Building expensive but seldom-used infrastructure incurs capital costs that get passed to customers through higher rates.

Payments for DR equipment. Some programs compensate participants for a full audit of their operation, for buying and operating backup generators, or for installing automated controls that can assist with carrying out DR measures.

Payments to determine DR potential (technical assistance). To help businesses develop a DR strategy, some utilities pay for technical assistance (audits and feasibility studies); others will do an audit to help determine what contributes to peak energy use.

Enhanced energy security. Energy security is a critical benefit of demand response. Blackouts impose tremendous economic and social costs, including equipment damage, lost revenue from damaged or spoiled products, lost wages, and reduced productivity. Such situations can be mitigated or prevented by increased participation in DR programs. Enhanced energy security through demand response comes from the diversity of hundreds to thousands of customers providing the equivalent benefit of one large generator.

4 HOW WILL DEMAND RESPONSE AFFECT MY BUSINESS?

Short-term DR actions that reduce energy use at your business can be inconvenient. However, working with your utility or a DR provider allows you to craft a program using measures that your business can handle, while at the same time improving your bottom line. Some of the issues to consider before you enroll in a program are the duration and frequency of the events, the comfort and convenience of your staff, and the program partnership with your DR provider.

Duration. DR strategies for businesses often need to be active for short periods, and you should only include reduction measures that your staff and operations can tolerate for the specified length of time. DR events commonly last 4 to 6 hours. Many businesses accommodate this sort of event regularly and without harm to their operations or bottom line. Most DR programs have limits on the number and duration of events they are allowed to call from a particular customer. Conventional DR programs are typically used no more than 80 to 100 hours per year.

Comfort and convenience. Depending on the level of automation of the building’s controls, facility managers or staff responsible for responding to an event may have to engage in a variety of activities to reduce on-site loads (such as dimming lights, curtailing motors, or engaging temperature setbacks either manually or through a control system). Depending on the systems affected, building occupants may not notice at all when curtailment occurs, they may notice and not be bothered, or they may be more substantially inconvenienced. In addition, the program you choose may have an “opt-out” alternative if your business is in a situation where you may not wish to engage in demand response.

Partnership. Utilities, their DR providers, and businesses can become partners through participation in DR programs. Your utility or DR provider may offer technical assistance to determine the level of response your business can commit to in a DR event while continuing to maintain the required level of convenience and comfort for your operations, staff, and clients. Such partnerships can also help you take advantage of other utility programs and incentives that promote efficiency and cost savings.

5 ARE YOU A GOOD CANDIDATE FOR DEMAND RESPONSE?

You can work with your DR provider to conduct an audit that examines your business' energy loads and determines whether your facility's peak demand coincides with the utility's, and what operational flexibility your business might have in changing when and how you use energy. If your business has some flexibility, then this list of questions can help determine whether you are a good candidate for demand response:

- Is your electrical peak demand within the range specified by your local electric utility's program?
- Do you have some large loads that can be curtailed (either all at one facility or aggregated over multiple sites)?
- Do you have many non-essential loads (such as decorative fountains or lights in unoccupied areas)?
- Could you change the temperature or lighting levels without disruption to your business?
- Can you temporarily curtail process loads, or could you temporarily shift some loads to different times of the day?
- Do you have standby generators that could meet some or all of your power needs for a few hours?
- Do you have the staff, procedures, and energy management controls in place to operate your building's equipment in real time?

- Do you have a building automation system (BAS) that controls significant portions of your lighting, HVAC, or process equipment and that can help implement a DR protocol?
- Are you in a highly competitive business where DR payments could help your bottom line?
- Would management put its support behind receiving payments for DR actions?

If you have answered yes to some of these questions, DR may be a revenue-generating opportunity for your business. Talk with your utility representative or DR provider about how these programs can add to your bottom line with minimal disruption to your operations.

6 TYPES OF DR PROGRAMS

a. Price-Based Versus Payment-Based

In **price-based programs**, as the name implies, customers are encouraged to curb demand because electricity prices are set higher at peak times. For example, in a heat wave, a utility with a critical-peak pricing program would notify its customers of a price hike for certain days and times, and customers would reduce their use if they are not willing to pay the high price. In contrast, **payment-based programs** involve either a flat fee paid out for certain actions—such as direct load control by the utility or DR provider—or a payment that can vary depending on the value the utility puts on your reduced demand (Table 1, next page).

Many factors may increase the payment a business receives for participating in DR programs, including:

- *Event notification lead time*. The less time you are given to respond, the more you get paid.
- *Maximum number of events*. The more often your resource can be used, the more you get paid.
- *Event duration.* The more hours your resource can be used, the more you get paid.
- *Event window.* The more flexible you are about the times your resource can be used, the more you get paid.
- *Number of consecutive event days*. The more days in a row you can respond, the more you get paid.

Table 1—Characteristics of price-based and payment-based demand response programs

Program type	Description
Price-based programs	
Critical-peak pricing (CPP)	Rates that include a prespecified extra-high rate that is triggered by the utility and is in effect for a limited number of hours
Interruptible or curtailable rates	Customers receive a discounted rate for agreeing to reduce load on request
Payment-based programs	
Direct load control	Customers receive payments for allowing the utility a degree of control over certain equipment
Customer load management	Customers receive payments for load reductions (for grid reliability, in emergency situations, to enhance capacity)
Capacity programs	Customers receive payments to make their demand response capacity available in case of an event
Demand bidding or buyback programs	Customers offer bids to curtail load when wholesale market prices are high

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- *Firm commitment.* The more willing you are to commit to a certain level of curtailment, the more you get paid.

b. Voluntary Versus Mandatory

Many DR program requirements vary on whether participation in each event is optional or mandatory, giving business customers even more choices—and more potential rewards. Your utility or DR provider can help you choose the program that best suits your operations, ensuring that you receive the greatest benefit with the least amount of risk.

Voluntary. If you enroll in a voluntary program, you can decide on a case-by-case basis whether to participate when called upon by the utility. By definition, a voluntary program will have a procedure for your business to opt out of responding to the event. Generally, if you opt out, you will not be compensated. DR payments are normally lower for voluntary programs because your utility cannot always rely on your willingness to curtail when called upon.

Mandatory. With greater commitment comes a greater reward: Customers in mandatory programs must comply with the utility's requests and reduce the amount of load to which they are contractually obligated—but these programs have higher payments. Failure to comply when enrolled in a mandatory DR program can result in penalties or ejection from the program. The reason for these seemingly harsh penalties is that mandatory programs are essentially a contract between the utility and its customers to provide demand response. If a business doesn't reduce their load according to its contract with a utility, the consequences could be extremely severe—even a blackout.

Check with your utility or DR provider about the rules for programs in your area.

7 FURTHER QUESTIONS FOR DR PROVIDERS

DR providers assist customers in signing up for system operator or utility DR programs. They normally get paid for enrolling customers. As their name implies, DR providers can pool the collective DR capability of a variety of facility types to provide a sizable block of capacity to the program. Depending on the contract between the DR provider and the utility, the provider may deduct a fee from DR payments before paying the customer. Such a fee will cover, among other things, costs for registration, identification of opportunities, customer service, communications, and managing risk to ensure that contract commitments between the utility and DR provider are met.

If DR providers are operating programs on behalf of your local utility or system operator, there are more questions you should ask them:

- Can you provide me with references of other businesses you have worked with?
- Will I pay any up-front charges to get started?
- Will I need to replace my meter?
- How will I be informed of curtailment events?
- How will you calculate my payments?
- How frequently will I be paid, and how is the payment delivered?
- If we don’t manage to curtail as much as we promised, do you take responsibility for penalties?
- Do you offer DR audits?

- Will you assist me with technical support and equipment designed to automate a coordinated response?
- What type of communications protocol will be established between our companies?
- How will I know whether or not I am succeeding in providing demand response during an event?
- What level of customer service can I expect?

8 HOW DOES A DR PROGRAM WORK?

When a DR event is called, participants are notified that they need to put their DR plan into action. Normally, the reductions are sustained for the duration of the event. After the event, the utility or DR provider verifies that demand was actually reduced by comparing meter data to a **baseline** (projected energy use in a "business-as-usual" case, with some modifications for weather or other factors). DR program participants that successfully reduce demand are paid for their performance. The timeline in Figure 3 breaks out the different phases of a DR event, with each phase discussed in more detail below.

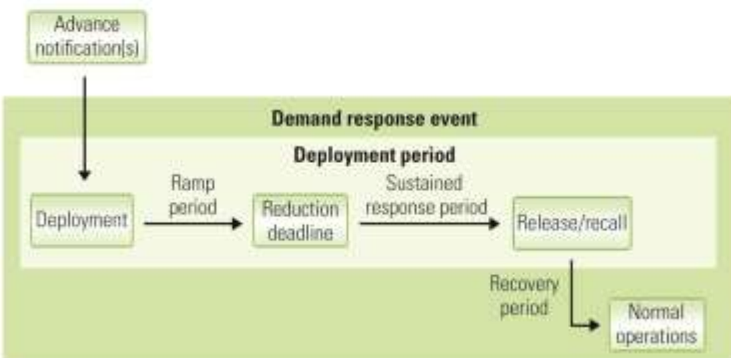

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Figure 3—Phases of a demand response event

Notification of an event. All DR programs provide advance notification about when a curtailment event will be triggered, but how much notification depends on the program and payments offered. For some programs, this notification is "day ahead"—the extra response time allows participants to prepare building occupants, work processes, and daily schedules. However, some programs have options for advance notice of two hours or less. Though this might seem difficult, the payments offered for short-notice demand response may be correspondingly higher. Advance notification will occur by phone call, pager signal, e-mail, or some combination of messaging, as arranged with individual clients.

Implementing your DR plan. Upon receiving notification, facilities engage in a pre-arranged set of actions that will reduce demand. Some DR programs involve direct control of HVAC loads through an automated notification and response mechanism. This externally-controlled response, or **direct load control**, is increasingly an option for smaller businesses, which participate simply by signing up and having suitable controls installed. On a very hot day, a DR event might be called because of surging air conditioner use. As agreed in the DR plan, the utility would remotely cycle (turn off and on) the company's air conditioner for the afternoon to reduce demand during peak hours.

Most DR programs move beyond direct load control and involve more complex actions due to the equipment or processes involved. When an event starts, a customer will implement a number of actions manually, such as shutting down equipment across a facility or coordinating the shutdown of a complex production line. On the other hand, a facility may have a BAS that the facility manager can use to convey preset commands to equipment and appliances to reduce their energy consumption. When an event is called, that command would initiate an automated DR routine. Although such a BAS could be under direct load control, there may be important reasons why the facility manager needs to retain the ultimate right to make a decision to provide demand response.

Event duration. Your facility's DR strategy will be called into action for a preset amount of time. The duration varies depending on the circumstance and the program, but is normally between four and six hours.

Release or recall. When the event ends, your utility or DR provider will communicate again with program participants, notifying them that curtailment activity is no longer needed and businesses can return to normal operations.

9 GETTING PAID FOR DEMAND RESPONSE

Price-based demand response programs let the electricity pricing system act as a "stick" to get businesses to reduce their energy use. Utilities charge more during times of peak demand and DR events, and let the customer decide how to respond to the prices. Payment-based programs offer a "carrot" instead, paying participants based on their actual level of curtailment. The latter approach highlights the need to determine a facility's energy reduction by determining its actual use relative to what its load would have been. Such programs need to establish a baseline of typical energy use to compare with your actual electricity consumption in a DR event.

a. Estimating Your "Business as Usual" Demand

After an event, your utility or DR provider needs to evaluate how much energy you curtailed during the event—energy that you would have used had there been no DR event. This requires the utility or DR provider to measure your reduction against a projection of your expected "business as usual" demand. This estimate is called a baseline.

The difference between the baseline and the measured load is the demand reduction (in kW). The area between the baseline curve and the measured load curve is the total energy consumption avoided (in kWh) during the DR event (Figure 4, next page).

Another aspect of baseline energy use includes special conditions on the day of an event, such as extreme weather or operational changes due to an unexpected order for goods requiring fulfillment before an event. Baseline use compared with actual measured demand on the day of the event will determine your DR payment, usually per kilowatt of sustained reduction in demand. Taking into consideration more recent patterns of energy use can significantly improve the accuracy of this type of baseline.

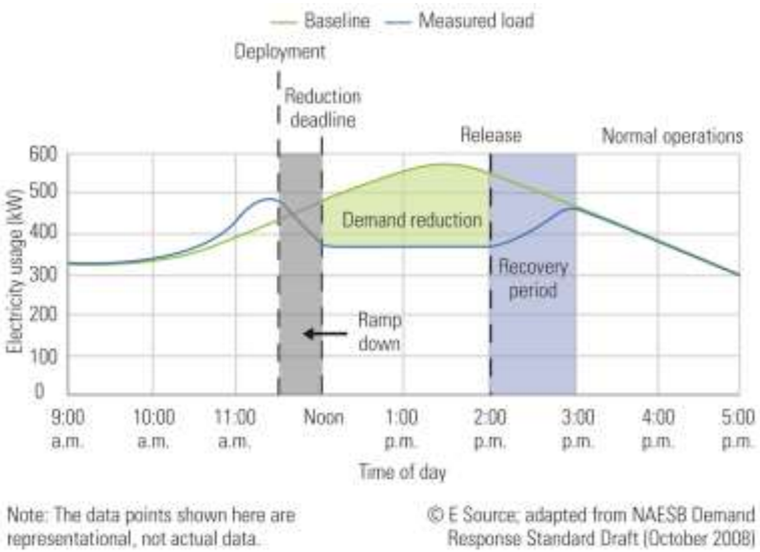


Figure 4—Projected baseline load relative to actual measured load in a DR event

Because nobody knows exactly what would have happened in the absence of an event, utilities and DR providers use various methods to estimate baseline electricity demand. This is often done by building up the baseline demand curve hour by hour for an event day, using an average demand for each hour on prior days. Increasingly, utilities and DR providers are constructing a baseline based on recent average energy use, using the 3 to 10 highest consumption days out of the 10 working days immediately preceding the event day. Depending on the DR program, the baseline may be adjusted to take into consideration higher or lower energy use than the expected baseline on the day of an event; this is frequently called a **day-of adjustment**.

b. Calculating the Baseline

As an example of how a baseline is constructed, consider a program using a “3 in 10” baseline with a day-of adjustment: The utility calculates an average demand for each hour, using the hottest 3 days out of the past 10 weekdays prior to an event (excluding event days and holidays). This value is then adjusted by using a ratio of the average load of several hours before the event to that of the same hours from those 10 weekdays. The result is compared with the amount of energy being used on the event day, which can be used to adjust the baseline.

So let’s say a business used 1 megawatt during the hours of 2:00 p.m. and 5:00 p.m. on the 3 hottest days of the past 10 working days. The baseline energy use for that business—the expected demand for energy on the afternoon of the next day—would be 1 megawatt. When an event is called the morning of the next day, the utility or DR provider would take into consideration energy use on the day of the event and make a day-of adjustment: The event is to take place from 2:00 to 4:00 p.m., but that day is unusually hot, and the business is using 1.1 megawatts between noon and 2:00 p.m., just prior to the event. So the baseline would be adjusted upwards by 0.1 megawatts, raising the level of compensation.

A similar adjustment can be used to reduce a business' baseline (a downward adjustment) if energy use just before an event is lower than expected. Because some facilities need time to ramp down their equipment and processes before a DR event, the day-of demand measurement will often be taken an hour or more before the actual event rather than right before an event. This delay between establishing day-of demand and the actual event permits facilities to start their shutdown procedures just before an event, without being penalized by a downward adjustment in their baseline. Talk with your utility or DR provider about compensation for different programs, and what kind of baseline will be used.

c. Measurement, Verification, and Compensation

Certain types of metering technology might be required if your business engages in a DR program that requires a baseline. Accurate measurement and verification of demand reduction compared to the baseline is critical to appropriately compensate DR program participants. Therefore, it is very important in any program involving baseline calculations for the energy customer and the utility or DR provider to work together on installing proper metering technology to make program participation viable.

Programs typically require, at a minimum, an **interval meter**, which can capture changes in demand and consumption at regular time intervals (typically 15 minutes, but some programs require 5-minute or 60-minute interval data). Contrast that with a standard revenue meter, which accumulates readings over time (total kWh/month), or a demand meter with a ratchet function that records the highest values since the last time the meter was read without specifying when those peaks happened. Some more advanced interval meters have **telemetry** (automatic and continuous communications with the utility or DR provider), so that the program operator can read meter data remotely and often in near-real time.

In either case, this data transfer ensures that your actual load during an event is properly measured and recorded. The accuracy of these data then allows for comparison of actual measured load against your baseline, and the calculation of your payment.

Interval meters collect “pulse” data readings of your electric load over certain time periods. Hourly intervals are generally used, but smaller intervals are becoming more common, especially for short-notice, short-duration DR programs. A process called **validation, editing, and estimating** (VEE) takes place behind the scenes to check data quality and verify overall demand reduction. Only then can compensation be made to individual customers (Figure 5, next page).

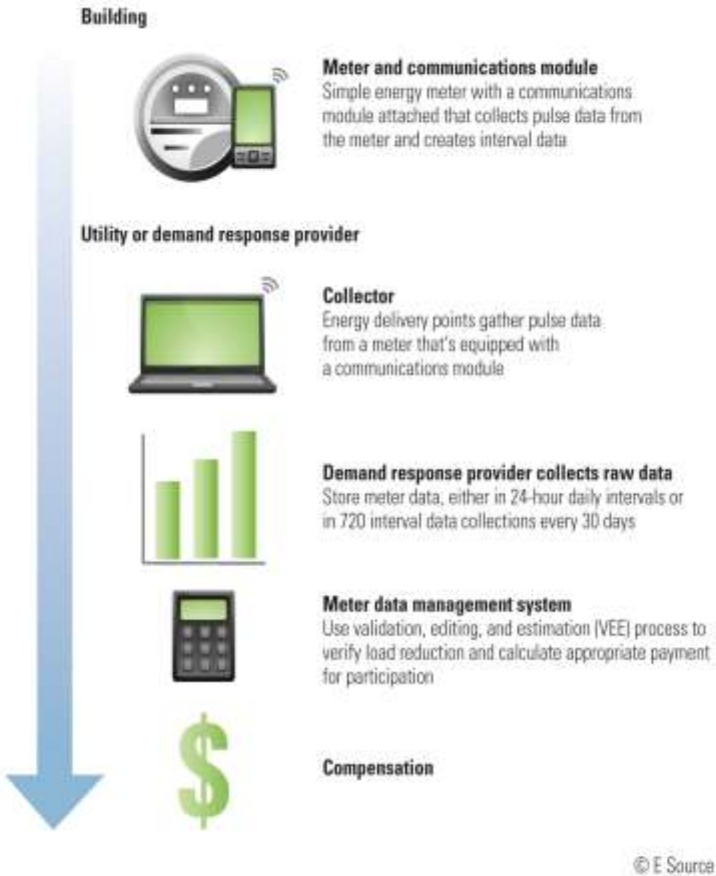


Figure 5—Flow of data from meters to utility or DR provider

Interval meters not only make proper compensation possible for customers, but they also make it possible for utilities and grid operators to accurately measure available load. If you commit to a 10 percent reduction in demand, your utility or DR provider will analyze your energy use relative to your baseline and will require multiple readings at appropriate intervals in order to verify your 10 percent reduction during the event. These readings could be as frequent as every five minutes and may depend on the format used by your provider to determine monthly demand. This process is very important in reliability events—utilities need to be certain about how much demand is being reduced so that they can prevent grid failure. At the same time, you want lots of data points to verify that you were putting in your best effort on your DR plan and should be compensated accordingly.

10 DR STRATEGIES

Frequently, businesses work closely with utilities or DR providers to develop a customized DR plan. This collaborative process helps to determine how much response your business can provide in an event while continuing to maintain the required levels of convenience and comfort. Such partnerships can also help you take advantage of other utility programs and payments that promote efficiency and cost savings.

The actions of a response plan might be carried out manually by your facility manager or designated employees, implemented automatically using a BAS, or done via some combination of manual and automatic response. A DR plan involves assessing your physical assets and the organizational structure with an audit of the business to determine the most effective ways to reduce demand. Each facility's plan will have a unique combination of tactics that shift load, shed load, or displace utility-supplied energy with on-site generation or storage.

- In a **load-shedding** strategy, your business can forego some uses of electricity—for example, during a DR event, an office building might reduce lighting levels or take some elevators out of service; an industrial facility might shut down ancillary equipment.
- With **load shifting**, your business can move electricity consumption to a time period outside the DR event or when the price of electricity is lower. For example, office buildings might pre-cool spaces early in the day during off-peak hours to avoid cooling in the afternoon during peak demand; an industrial facility might defer some production processes to an evening,

overnight, or weekend shift. Storing energy at off-peak hours to be used during peak hours is another example of load shifting.

- And **load displacement** means that your business can generate energy using on-site standby generating equipment, thus reducing consumption of power from the grid. Load-displacement activities are often complementary to load-shedding activities.

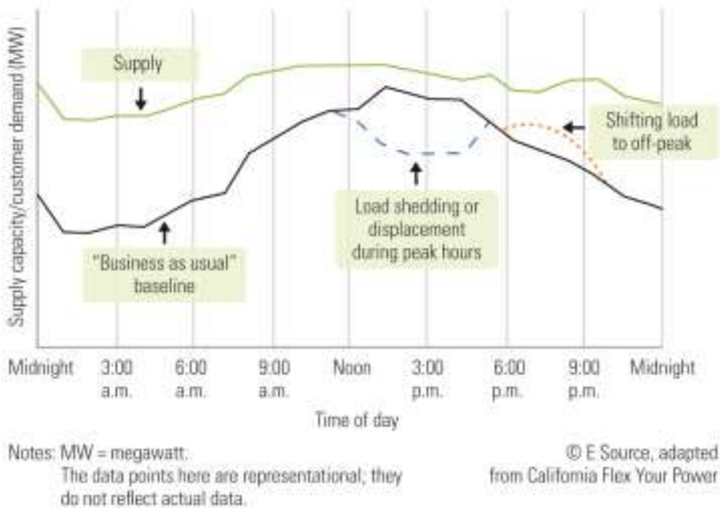


Figure 6—Peak load management options

Utility customers using DR strategies change the overall load for their utility on an event day. Figure 6 shows a "business as usual" energy consumption profile, in which the load for the utility shown would be approaching available electricity supply during the peak hours of noon to 7:00 p.m. Customers who reduce their demand by shedding or displacing load reduce overall peak demand on the grid during the event. Customers who shift load to off-peak hours might be moving production to a night shift—they are still using the energy they need for business operations, but not during the event.

a. Shifting and Shedding Load

Some major components of a DR strategy of shifting or shedding load fall into the general categories of behavioral changes and process changes.

Behavioral changes. The most important energy uses in many buildings are space cooling, lighting, and fans. Common facility management practices include turning off specific lights or light circuits, shutting off non-essential appliances, changing thermostat settings on space-conditioning systems to reduce operating times, cycling or curbing ventilation fans, and shifting cleaning and maintenance crews to off-peak hours. These are relatively low-risk options that are primarily based on changes in behavior, and they are frequently featured in DR strategies for retail and office-type businesses.

Process changes. Industrial production processes have larger opportunities and potential benefits from demand response. Most opportunities come from scheduling changes to production processes. Some of these measures are appropriate for ongoing peak reduction by load shedding, and others are appropriate for more drastic temporary load reduction, as in payment-based DR programs. Medium-risk options include slowing down processes or curtailing less-important parts of processes. Higher-risk options include stopping the production on a wide scale and shifting that production to earlier or later in the day. However, even some of these more dramatic production changes can be readily accommodated with good planning and management.

b. Using a BAS to Implement DR Strategies

A building automation system can facilitate the implementation of DR strategies that are behavioral or process-oriented. Depending on the features of your BAS, it can turn off or turn down HVAC equipment, lights, or industrial processes, either automatically or with some manual intervention. Some BAS systems have the capability to automatically respond to DR signals, using preprogrammed control strategies to curtail building energy use. Even BASs that are not capable of an automated response can still be used with a DR program. When building operators receive a DR signal, they can either activate preprogrammed control strategies in the BAS or manually turn off or down building systems using the BAS controls.

A building automation system consists of sensors, controllers, actuators, and software. An operator interfaces with the system via a central workstation or web browser. DR signals can be fed to the workstation to initiate a response. If the BAS is not equipped to respond automatically, additional software can be added to the workstation to enable it to initiate the shutdown of building systems (Figure 7, next page).

It is also possible to upgrade an existing BAS to add DR functionality where it does not currently exist. For example, there are products that create gateways between an existing BAS and a building's lighting and pneumatic control systems.

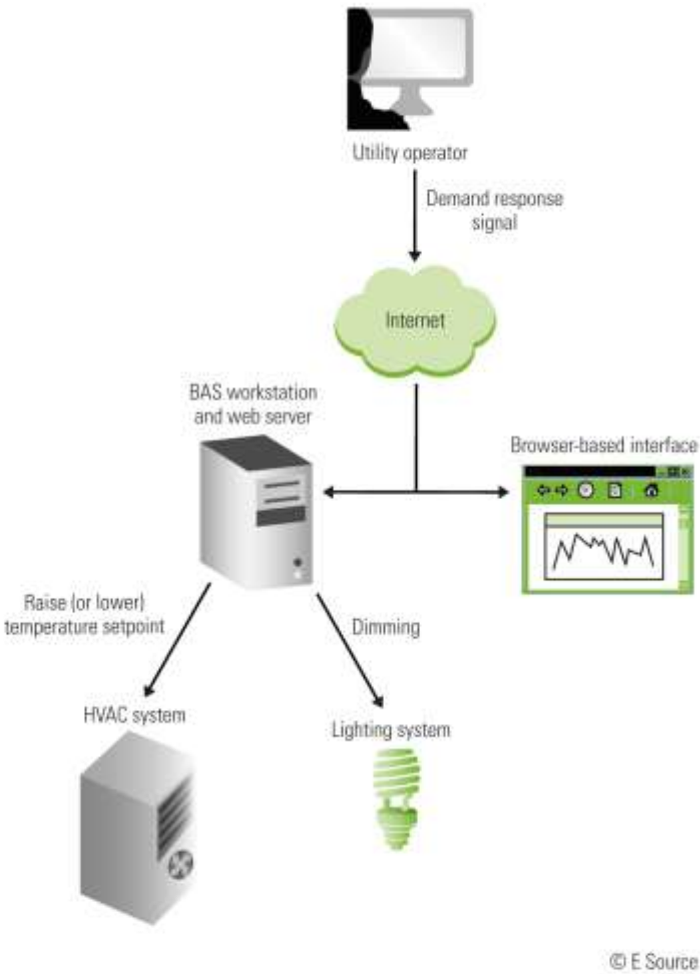


Figure 7—Demand response and BASs

When deciding whether to upgrade a current system or replace it entirely, it's important to first examine the current BAS vendor relationship and available equipment. In some cases, BAS manufacturers may no longer support older systems because they have a newer generation. If the current support is inadequate, it may be time to replace the entire system and possibly to move to a different vendor.

When upgrading or installing a BAS, the communication protocols used between system components can influence the vendor you select. The industry uses two major types of communication protocols for digital control systems: proprietary and open. Proprietary communications are used to link components of a particular manufacturer's equipment using an approach exclusive to that manufacturer. Open communication systems are based on public protocols available to all manufacturers. Although proprietary systems may allow backward or forward compatibility with other generations of equipment from the same manufacturer, they don't readily allow communication with other brands of equipment. Many manufacturers sell gateway devices, which convert one communication protocol to another, to increase the compatibility of their components with other manufacturers' components, but these gateways are expensive and often require patching and upgrading when there are changes in either protocol.

Systems that rely on proprietary communications are rapidly disappearing from the marketplace. Because such systems are limited in their ability to communicate with others, choices for expanding this type of BAS are limited. Proprietary communications also reduce choices when you're purchasing new equipment, thus limiting your bargaining power. However, proprietary systems do offer the advantage of a single source of responsibility when there are problems. Proprietary systems can also offer higher performance because they don't have to make compromises to comply with open standards.

There are several well-known open communication systems in use. For building automation, BACnet and LonWorks are the two primary choices for open communications. Although these protocols differ in their approach to achieve interoperability (the ability of controllers to work together in an integrated fashion), both have been successful at creating interoperable systems. BACnet was created by ASHRAE (the American Society of Heating, Refrigerating, and Air-Conditioning Engineers) to provide a standard protocol that all manufacturers could use. LonWorks was developed by Echelon Corp., a control networks manufacturer, for similar reasons—but LonWorks requires that a proprietary chip be embedded in all control devices used in a LonWorks network. Currently, BACnet appears to be the dominant open protocol in the building automation market.

Open systems are trending toward technology-neutral communications based on web services (using basic web languages and universally available Internet connections). To compare the advantages of each open protocol standard for a given system, seek assistance from a building controls designer.

There are several advantages to using an open communication protocol for a BAS. First, there's the assurance that the system will be able to interact with equipment from multiple manufacturers that support the same protocol. Also, open protocols will help facility managers reduce system costs because they create a competitive bidding environment for system additions and renovations. Lastly, because the system is being monitored by a centrally controlled computer, if you always specify open protocols for system components, the central controller equipment from the manufacturer of your choice should be able to interface with all equipment in your facility.

Finally, BASs can also implement demand-limiting strategies. When the BAS sees that the demand on a building meter or piece of equipment, such as a chiller, approaches a predetermined setpoint, it will not allow the equipment to load up any further. Other uses for BASs will emerge as utilities implement time-of-day or real-time electrical pricing in their rate structures.

c. On-Site Generation: Converting Sunken Capital Costs to DR Benefits

Many C&I facilities have installed backup generation systems as insurance against the possibility of inconsistent grid power. Currently, many of these systems are installed as emergency power resources; they are only expected to support a limited load over a short time frame. Many industries, such as data centers, find it vital to be able maintain power even during regional blackouts, and a redundant backup generation system can provide this assurance. Generators can be brought on-line immediately and provide dependable power in case of emergency, but they require a significant up-front capital investment and will be utilized only rarely. Demand response offers an opportunity to realize additional income from generators by displacing a portion of peak load during a DR event.

There are three primary configurations between backup generators and the local grid:

- **Islanded generation with an automatic switch between generator and grid.** Most backup generation today operates this way; it is often referred to as **automatic islanding**. During a blackout or brownout, the on-site generation system disconnects the facility from the grid or isolates a circuit and then provides power locally.
- **Parallel operation with local grid and no power export.** These systems are designed to operate while connected to the grid but will not provide more power than is consumed at the facility. They are usually found at large industrial facilities. This type includes facilities that generate their own power and take advantage of the waste heat through combined heat and power. Increasing numbers of small and midsize facilities are showing interest in parallel generator installations as the price of the technology decreases.
- **Parallel operation with local grid and power export to grid.** These systems allow integrating backup generation into the local electrical grid—a setup that can not only increase overall grid stability but can also prove to be financially beneficial to the owner of the generation. This type of interconnection is rare, but it has significant potential to improve the economic and environmental efficiency of the whole system.

As shown in Figure 8 (next page), generators in an islanded configuration will automatically disconnect from the grid in the event of disruption. In a parallel configuration, generators will not be disconnected; they will instead operate in tandem with the grid, supplying partial energy to a facility or even exporting energy back to the grid.

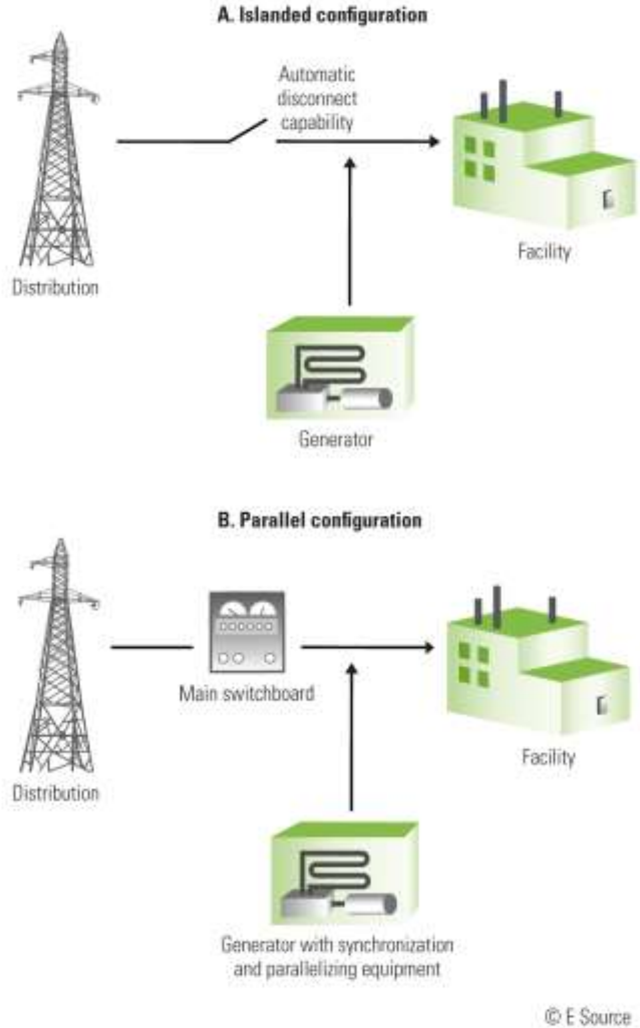


Figure 8—Islanded (A) and parallel (B) configuration of on-site generators

The majority of the systems installed for backup generation fall into the category of islanded generation. These systems serve a useful purpose in emergencies, but there is no exchange of energy possible between the generator and the grid. The grid can't help the facility when it needs assistance during a blackout, and the facility can't support the grid when it needs extra capacity during peak load.

Parallel generator configuration, on the other hand, allows on-site generators to produce power for a facility while it is still receiving some power from the grid. Parallel configuration requires a greater investment in infrastructure, but it allows end-use customers to increase revenues from their generator systems by providing on-site demand response, potentially exporting energy back to the grid, and assisting in the maintenance of overall grid stability, which supports a healthy business environment.

It is important to work with the local utility to determine whether dispatchable distributed generation is allowed and what the necessary infrastructure would be. Some of the most common generator controls include:

- An exciter control system.
- A synchronizer for the reliable transfer of power back to the grid.
- An automatic transfer switch control.
- Import/export control to manage power transfer to and from the grid.
- Protective relay functions to maintain power quality to the specifications of the utility.

- Remote communication capabilities that allow a utility to control on-site generators and track fuel levels to assess response potential for each unit controlled.

Moving beyond simple islanding to controlling generation that is running in parallel with the grid is more complicated than simply switching on the generator when the lights go out. However, it is manageable with existing off-the-shelf equipment, and technical assistance may be available from your utility or DR provider.

Emissions are a consideration when using on-site generation. Many backup systems run on diesel fuel, which can emit more pollutants relative to how many kWh they put into the system than power plants do. In many areas, there are restrictions about how often and under what situations generators can be used. It may be necessary for a facility to apply for different environmental permits if it intends to operate as an intermittent generator for longer hours under DR conditions, as opposed to operating only in emergencies. Businesses should work with their local air-quality authorities as well as their utility or DR provider to address any regulatory requirements before integrating a generator into their DR strategy.

d. Storage as a Demand-Limiting Tool

Energy storage technologies receive energy produced at times of low demand and release that energy at times of high demand, thus shifting part of a facility's overall electric load to off-peak times. The storage medium is **charging** when it is receiving energy (often at night) and **discharging** when it is releasing energy during the day, displacing load that a business would otherwise obtain from the grid during peak times.

Energy storage is primarily used in the large industrial, commercial, or institutional sectors to avoid higher charges during peak demand periods. These businesses can afford the significant up-front costs associated with most forms of energy storage, and they make it cost-effective by using the systems regularly to shift their loads. This load shifting helps shave very high daytime peaks, but it is an ongoing form of demand reduction rather than event-specific demand response. The stored electricity becomes integrated into a facility's base load.

Although some existing storage technologies can be used as a dispatchable resource for demand response, those technologies often have limitations such as high up-front costs or slow dispatch times. Some emerging storage technologies offer hope for cost-effective, readily dispatchable power, but they are many years away from being a convenient and affordable business solution outside of utility-scale applications. In general, energy storage applications are best suited to DR programs that focus on sustained load shifting.

Most storage technologies release energy during peak hours on a consistent basis and are therefore considered peak-shaving technologies. Some, like batteries, can be dispatched for demand response but are not yet cost-effective for small and midsize facilities (see Table 2).

Pumped hydro. This is the most common form of potential energy storage, and it uses electricity when rates are lowest to charge the system by pumping water from a lower to a higher reservoir. When electric demand is highest, the water is released, or discharged, down a waterway and through a turbine to generate electric energy. Though pumped hydro is most often used for peak shaving, it could potentially be used as a DR technology if sufficient notice was provided in advance of an event. However, it tends to be a very large-scale application.

Table 2—Conventional and emerging energy storage technologies and their primary applications

Storage technology	Time required to dispatch	Primary use
Conventional systems		
Pumped hydro	Several hours	Peak shaving
Compressed air	About 15 minutes	Peak shaving
Nickel-cadmium batteries	Instantaneous	Power tools
Lead-acid batteries	Instantaneous	UPS systems
Built-up ice storage systems	<1 minute	Load shifting
Electric thermal storage	Instantaneous	Load shifting
Emerging technologies		
Lithium-ion batteries	Instantaneous	Frequency regulation and spinning reserve
Flow batteries	Instantaneous	Grid backup power
Direct-expansion ice storage systems (Ice Bear)	<1 minute	Load shifting
Flywheels	Instantaneous	Frequency regulation

Note: UPS = uninterruptible power supply.

Compressed-air storage. This type of storage increases the potential energy of air by compressing, or charging, it when electric rates are lowest and releasing—discharging—it through a combustion turbine generator when electric demand is highest. The most practical use for compressed-air storage is to store air at a higher pressure for use at a lower pressure in air-powered tools and process applications, which can reduce energy consumption and demand during DR events and limit demand during peak periods. Small compressed-air systems use tanks or large high-pressure pipes as storage; larger systems use underground geologic formations such as depleted natural gas fields, caverns, and aquifers as reservoirs. As with pumped hydro, compressed-air storage is most often used for peak shaving, but it could be used as a DR technology.

Thermal storage. There are two major categories of thermal storage—electric heat and ice or chilled water. Electric thermal storage stores electric heat during nighttime hours when rates are lower. The most common type of electric thermal storage uses a resistance heater with elements encased in heat-storing ceramic. Central furnaces incorporating ceramic blocks are also available, though they are not as common as room heaters. Storing electrically-heated hot water in an insulated storage tank is another thermal storage option. Unlike many storage technologies, electric thermal storage is suited for small facilities as well as large ones, if the building has room for extra storage tanks, blocks, or bricks to retain heat. It is also better to locate these heat-storing technologies within buildings, or even below them, to better insulate them and prevent rapid energy loss.

Ice or chilled water is the other primary thermal energy storage mechanism. This technology uses direct expansion (DX) packaged units or chillers to charge insulated storage tanks with ice or chilled water. During peak demand, the ice is melted and discharged to the air handler's coils to provide cooling. Reliable reduction of 95 percent of the on-peak cooling load is the most important performance criterion of cool thermal storage. Thermal storage systems coupled with chillers, called **built-up** systems, are uniquely designed for and built into specific chillers on specific buildings.

Recently, an ice storage unit called the Ice Bear (Figure 9, next page) has been designed for 5-ton DX-packaged units, to mitigate their contribution to the summer peak air-conditioning load. The Ice Bear charges its storage tank with ice at night, taking advantage of cooler temperatures and diurnal effects, and discharges the ice as chilled water to its evaporator coil (installed in the existing DX unit) during daytime peak demand periods. During discharge, the power consumption is reduced to the draw of a chilled-water pump and the DX unit's fan.

Although these ice storage systems could be used for demand response, their high up-front cost requires that, to be cost-effective, they are used on a daily basis for peak shaving. This usage pattern would make them unavailable for demand response.

Batteries. Electrochemical batteries are the most common chemical storage mechanism, using a chemical reaction to create a flow of electrons (electric current). Lead-acid, nickel-cadmium (NiCad), and lithium-ion (Li-ion) are examples of electrochemical batteries. Flow batteries differ from electrochemical batteries in that they store the electrolyte in a tank that is separate from the battery cell container. The

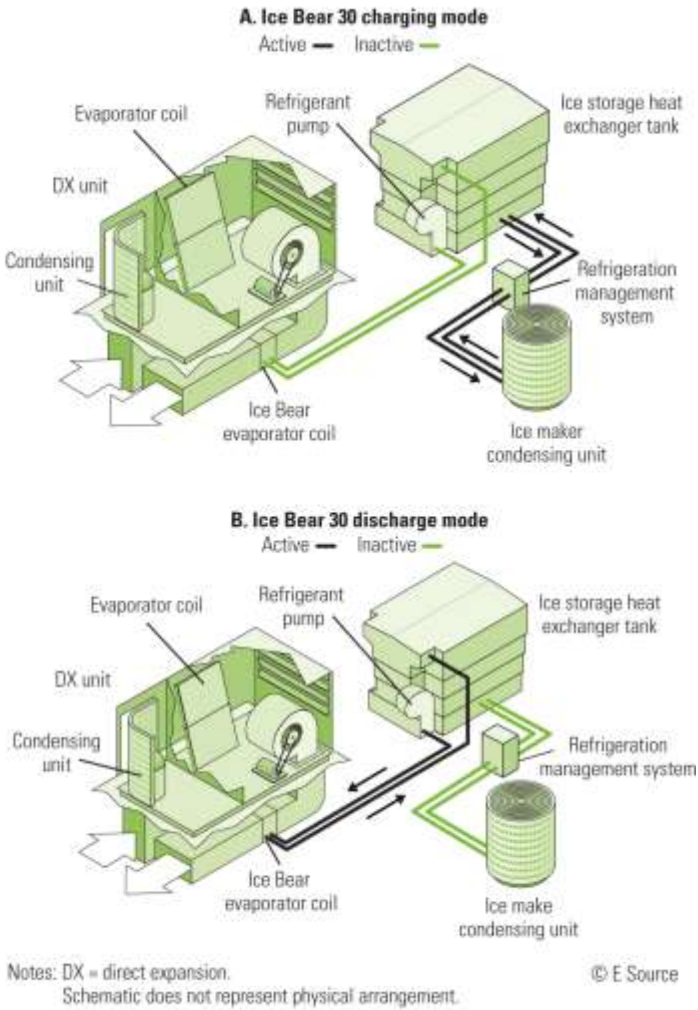


Figure 9—Thermal storage in action: An Ice Bear 30 in charging and discharging modes

advantages of this configuration are that the electrolyte can more easily be replenished when it becomes degraded and additional electrolyte can be added to lengthen the duration of discharge if necessary. With their instantaneous dispatch time, both types of batteries can be effective DR technologies. Their high cost, however, whether in the conventional or emerging technology category, prevents them from being an affordable DR solution for most businesses at this time.

Flywheels. Flywheels store kinetic energy by increasing the rotation of a massive cylinder attached to a shaft in a low-vacuum, near-frictionless environment. The motor charges the system by increasing the flywheel's rotational speed; the generator then discharges the system by converting the stored kinetic energy into electricity, slowing the flywheel's rotational speed. This technology could potentially be used for demand response, but it is normally large-scale and expensive, and is therefore not likely to be cost-effective for limited uses on DR events alone.

Production storage. This can come in several forms, from simply storing product in a warehouse in anticipation of a DR event, or stockpiling raw product (such as pulp, in the pulp and paper industry).

11 DEMAND RESPONSE IS DIFFERENT FROM EFFICIENCY

Demand response involves activities you do only occasionally because they may require extra time or cause additional inconvenience. It occurs at very specific times, for limited durations, and generally requires a sacrifice of some convenience or comfort in return for payments. In contrast, energy efficiency is occurring all the time, usually because your business has installed technologies that provide you with the same or improved services while using less energy. Energy efficiency does not generally require a sacrifice in the level of services or comfort, and it provides benefits over the longer term.

Sometimes, preparing for DR events identifies energy use patterns that can be permanently changed for long-term

The Difference Between Energy Efficiency and Demand Response, Simplified

Energy service providers in New England offer customers a clever way to understand the difference between energy efficiency and demand response:

- “Energy efficiency is like buying a car that gets high gas mileage.”
- “Demand response is like limiting your driving when gas prices are high (price) or the roads are congested (reliability).”

energy efficiency. For example, a DR audit may identify areas of a facility in which lighting can be dimmed all the time or may prompt the installation of occupancy sensors that keep lights off in unoccupied areas. These measures are inexpensive investments that create no negative effects on operations or staff, and they become energy efficiency measures—they reduce overall energy demand, but they also generate savings over time, not just during DR events.

Table 3 provides some key examples of the differences between demand response and energy efficiency. For example, right now you can engage in some low- or no-cost measures that save energy all the time (energy efficiency). Regular maintenance to fix leaks, cleaning condenser coils, and changing belts and filters can save up to 30 percent of fan energy and 10 percent of cooling costs annually. These energy-

Table 3—Technology strategies for demand response versus energy efficiency

Technology	Demand response	Energy efficiency
Lighting	Dim or shut off lights in all areas	Install permanent motion sensors that automatically shut off lights in unused areas
HVAC	Change temperature setpoints up in warm weather or down in cold weather by more than normal	Change temperature setpoints up or down (depending on season) a small amount as a permanent measure
	Shut off air conditioning and only run fans	Install a time clock or building control system to turn off the system when the building is unoccupied
Office equipment	Power down or unplug unnecessary equipment during the event	Enable sleep modes on computers and power management settings on copiers, printers, and fax machines; plug all appliances into smart power cords that prevent "vampire" power draw at all times

efficiency measures lower your overall demand because your operation is always using less energy once they are implemented. Then, during a DR event, additional actions can be taken to further reduce your load during a specific timeframe.

Lights, air handling and conditioning, and appliances or process equipment are used differently depending on whether a DR event requires immediate and temporary reduction in load or whether a business is striving for overall reduction in energy use on a consistent basis. Note that some DR strategies can be adapted from temporary short-term use to create ongoing savings, thereby increasing energy efficiency (Table 3).

a. Turning Demand Response into Long-Term Energy Savings

Because demand response is normally only needed for a limited time frame, some businesses can make very deep cuts in energy use during events. Some of the measures that businesses take for DR may help them realize inefficiencies in how they use energy. For example, businesses learn that they can live with lower light levels in hallways, so they dim ballasts or remove some lamps to create savings all the time, not only during DR events. Some go further by installing motion sensors to reduce lighting needs for empty spaces. By standardizing short-term DR practices that at first seemed inconvenient and making these measures “normal,” C&I customers create energy-efficiency savings for the long term. Staff and clients do not perceive the new normal as a hardship, but accounting *will* notice that energy costs decrease as the company increases its energy efficiency.

b. What to Do If You've Already Invested in Energy Efficiency

If your business has already invested in various building control systems (an energy management system or BAS) that create energy efficiency, then you are in an even better position to participate in DR programs. Control systems allow you to preprogram HVAC and lighting settings to reduce consumption at times of peak demand. You will not have to manually adjust settings throughout your buildings because control systems enable a rapid and thorough response and make it easier for your business to capture payments from DR events. If you don't have such systems, talk with your utility or DR provider about options for technical assistance and possible payments to upgrade your building control technology.

12 FUTURE DIRECTIONS FOR DEMAND RESPONSE

a. Automated Demand Response

There are several levels of DR automation (Table 4). If you have an energy management system or a BAS, you already have some form of automation, which can make it easier for you to integrate demand response into your operations. Your facility manager can program criteria into the building's control system to respond to DR events automatically through a predetermined strategy. Your control system will curtail programmed loads according to schedule until the event is over. Depending upon your control system, Internet connectivity, and load profile, you may be able to develop this into a fully automated process, known as automated demand response (auto-DR).

Table 4—Levels of DR automation

Level of automation	Uses BAS?	How response occurs
Remote	No	Load (normally air conditioner, water heat, pool pumps) can be controlled, or "cycled," by utility via switch or radio signal
Manual demand response	No	People manually turn off lights and equipment when called upon to do so
Semiautomated demand response	Yes	A person initiates a control strategy preprogrammed into the BAS when a demand-response event is called
Fully automated demand response (auto-DR)	Yes	Receipt of an external communications signal automatically triggers a BAS control sequence that switches the building to low-power mode; no human intervention is required

Note: BAS = building automation system. © E Source; data from Kiliccote and Piette (2006)

Auto-DR systems respond instantaneously to electricity pricing and DR signals to initiate preprogrammed control strategies. When electricity prices are high or when the grid is nearing full capacity, preset control strategies shed or shift electric loads. Utilities are looking at auto-DR as a way to make it easier for businesses to participate in demand response. This approach has already been deployed successfully in California, and it is gaining momentum. Because auto-DR also relies on open, nonproprietary communication protocols, it poses few technology barriers for facilities that do not have dedicated engineers focusing on energy or load management. These characteristics make auto-DR a promising development in demand response for C&I facilities.

b. The Evolution of Demand Response

Demand response continues to evolve across North America in terms of program structures, payment levels, dispatch methods, degrees of commitment, and flexibility options. As this new capability for system operators and utilities continues to grow, customers should be aware that existing programs may change and new programs may be developed. Staying informed through your utility or DR provider is essential for successful participation in demand response.

13 APPENDIX: DEMAND RESPONSE BY SECTOR

a. Agriculture

This brief addresses two areas within agriculture that can present significant demand response (DR) opportunities: livestock or dairy farming and crop irrigation.

Livestock or Dairy Farming

Confined animal operations have intensive electric loads for the lighting and ventilation of the confined spaces to ensure animal health and productivity. Operations that also have value-added products (for example, in a dairy, bottling milk or making cheese, ice cream, butter, and yogurt), are essentially engaged in food processing, in which there are more options for demand response, including curtailing chillers, refrigerators, or packaging and labeling processes. Farm operations are not good candidates for DR programs unless there is value-added production on the farm site, because cows, poultry, and pigs are very sensitive to environmental conditions such as temperature and lighting. Changing these variables—even temporarily—is often viewed as an unacceptable risk to operational stability and business profitability.

Dairies in particular have excellent opportunities to curtail electrical load. The value-added processes many dairies engage in are less vulnerable to temperature or timing variations than animal production is. Delaying or curtailing operations can be successful DR strategies, particularly if adequate staff is available.

Farm-based facilities that process cold or frozen goods will have the most flexibility: Shutting down refrigeration while relying on thermal mass and well-insulated storage rooms or freezers to sustain cold temperatures can be an excellent DR strategy. Additionally, facilities that have packaging processes or dairies with culturing or pasteurization processes may have flexibility in delaying or curtailing some energy use.

Animal producers and their facility managers may never have seen their own load profile or used a building automation system (BAS). DR providers or utilities can help farm-based food processors understand the potential value of participation in DR programs by showing facility managers a profile of the farm’s energy use and working with them to determine strategies that can be used without risk of product spoilage or operational disruption.

Farm-based food processing can involve diverse equipment, depending on what value-added products will be made on the farm. For dairies, heating can be the largest energy user—heating is involved in pasteurization and condensing or evaporating milk—but heating may not necessarily entail an electrical load. For operations that involve such processes, refrigeration and ice-making can constitute a large electrical load—up to 80 percent of the total food processing load. There are often many small motors used in the conveyance and handling of food within a facility, from off-loading through packaging. Pumps and air compressors can also be larger loads. Lighting is normally not a significant load relative to the process loads in a farm-based food processing facility.

Backup power is often present at farm-based food processing facilities as protection against food spoilage. Because this equipment is already on-site, it is an available DR option as well as an emergency energy resource. There may also be some fuel-switching options, particularly in water heating, that can reduce the overall electrical demand.

One dairy with a value-added cheese production line achieved an 80 percent load reduction through participation in a DR program by turning off its compressors and letting the temperature float in the cold storage section of the operation. Demand was curtailed by 160 kW during a two-hour event (Figure A-1).

Human comfort is not a great concern within the agriculture industry, but animal health and food quality are critical. On

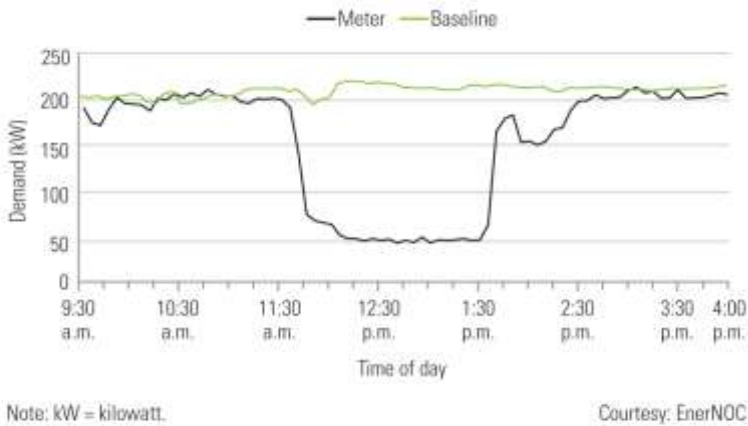


Figure A-1—Demand reduction in a dairy

the animal care and handling side, there is very little flexibilty for demand response. But because some farms make value-added products on-site, they can curtail some loads to both ensure product quality and benefit from DR incentives.

Typical DR Strategies for Livestock and Dairy Farming

Agricultural facilities can successfully contribute to load reductions using a number of proven strategies. These focus on refrigeration, pre-cooling, lighting, load shifting, and backup generation (Table A-1).

Shutting off refrigeration and freezers. Cold-storage areas for value-added products like cheese are excellent candidates for demand response. Even when these areas are entirely shut off, insulation of the space prevents thawing or temperature creep. Also, the thermal mass of the product itself provides insulation. But monitoring equipment is required to ensure that temperatures remain within regulatory requirements, and food processors must be prepared to end curtailment if temperatures rise too rapidly.

Table A-1—Strategies to reduce demand in agriculture

Demand response strategies
Shutting off refrigeration and freezers
Precooling
Shifting processes off peak
Curtailing lighting
Switching to on-site generation

Pre-cooling. Food processing facilities that have refrigerated warehouses can shift their load and reduce peak demands by pre-cooling to a lower temperature prior to the DR event, then allowing the temperature to rise naturally. The temperature will rise a few degrees and must be monitored to ensure that product quality is not compromised. A facility could also keep its cold products on ice until after the curtailment period to reduce demand on the refrigeration system.

Shifting processes off peak. If notice of a DR event is given in advance, some ancillary food processing operations can be performed before the curtailment or delayed until after the peak. For example, cutting and packaging of cheese or labeling milk bottles could be delayed without affecting product quality. Batch pasteurization could also be shifted without harming the product.

Curtailing lighting. Food processing areas of an agricultural facility may have large high-intensity discharge (HID) light fixtures in storage areas of their facilities that can be manually dimmed or turned off.

Switching to on-site generation. Many agricultural facilities have on-site backup generation and are good candidates for DR programs that allow the building's load to be shifted onto these generation sources. Switching to backup generation is usually immediate and causes no interruptions to service. However, because backup generation typically consists of diesel generators, local or provincial air-quality regulations may limit this strategy.

Crop Irrigation

As with livestock and dairy farming, the livelihood of the crop farmer is vulnerable to many environmental variables. These variables are often outside the control of the farmer, who has some influence on soil moisture, nutrient availability, and pests—and no influence on the weather. Crop irrigation is critical to the successful production of many grains, fruits, and vegetables. The electrical loads involved in growing-season irrigation can be enormous—hundreds and sometimes thousands of megawatts.

At the same time, incentives are critical to crop farmers. They are often willing to try new programs if the business case is convincing. Although agriculturalists must manage many variables to produce healthy crops (such as soil moisture content, crop type, and evapotranspiration rates), under some conditions, irrigation can be partially—or even fully—curtailed or shifted to off-peak hours, which can dramatically reduce summer load in rural electric districts.

Nighttime irrigation is gaining importance as a water conservation practice in addition to being an energy-management technique. Utility programs can use more attractive off-peak rates as well as incentives for curtailing peak daytime usage to encourage farmers to manually shut off some or all of their irrigation pumps or to allow timers to be installed that turn pumps off during peak hours. Direct load control switches are also an option that allows the utility or aggregator to remotely turn pumps off. Added incentives for participation include subsidized upgrades to irrigation equipment—some pumps can be over 80 years old, and a utility subsidy for replacing them might be considered an efficiency measure as well as an investment in DR participation.

Equipment that can be controlled during irrigation DR includes small well pumps (5 horsepower [hp]), booster pumps (20 to 50 hp), and multiple pivots served by each pump (20 to 30 hp).

There are also much larger pumping stations that can be controlled, depending on the size of any given farming operation and the terrain of the region. For example, pumps that move water from low-lying riverbeds to higher elevations can range up to 1,000 hp (nearly 750 kilowatts [kW]). Aggregating the irrigation pumps and pivots over a large agricultural area and curtailing them en masse yields tremendous DR benefits.

One utility program realized an average demand reduction of 60 kW per participant in a program in which timers were set to shut off nearly all pumps and pivots during late-afternoon peak hours (Figure A-2).

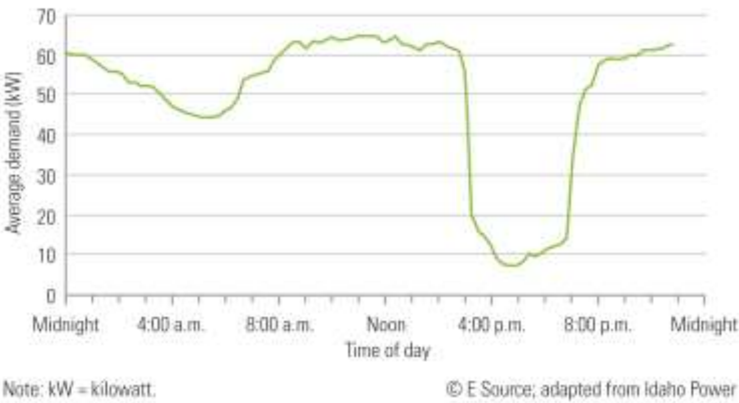


Figure A-2—Average participant load reduction in an irrigation timer DR program

Typical DR Strategies for Crop Irrigation

Shutting off irrigation pumps and pivots. The primary DR strategy for crop irrigation is a combination of load shedding and load shifting. Crop farmers may simply curtail use for a short event, or they may apply more water before or after peak hours. In particular, nighttime watering can be increased during DR event days. Utilities or DR providers can remotely curtail irrigation equipment using switches, enable curtailment using timers, or rely on manual DR by the farm staff.

How to Get Involved in DR for Agriculture

Contact your local DR provider. Either your utility or a DR provider working on the utility's behalf will meet with you, examine your operation to determine the most appropriate strategies for your situation, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

b. Food Processing

The food processing industry is exceedingly varied, both in terms of the products created and the equipment used. Some facilities only run a few months of the year, others run 24/7, and still others that make multiple products require different schedules or seasonal adjustments. Although they have large electrical loads, the type of food and the details of the on-site processing determine whether any given facility is a good candidate for demand response.

The "fresh pack" season for fruits and vegetables that are less processed runs from June through October in some climate zones, but may be more limited depending on climate and crop requirements. These plants are running at peak times and have a limited season in which to ensure their profitability. Therefore, they are less flexible to curtailment as they prepare fresh produce to move from fields to markets. Root vegetables are more resistant to spoilage than other products, and processors working with these crops may have the ability to curtail.

Products that are less seasonal—such as meat or seafood, which can be frozen raw and further processed any time of year—offer increased flexibility. Facilities that process chilled or frozen goods will have the most flexibility: Shutting down refrigeration and relying on thermal mass and well-insulated storage rooms or freezers to sustain cold temperatures can be an excellent DR strategy. Also, facilities with packaging processes may run two shifts or the entire day, but can have flexibility in delaying or curtailing some processes that could allow them to benefit from DR incentives.

The livelihood of a food processor depends on careful attention to food quality, so operations and processes are closely monitored. However, facility managers may never have seen their own load profile or used a BAS, especially in small and midsize operations. Even in larger operations, there is normally no dedicated energy manager on-site. DR providers or utilities can help food processors understand the potential value of participation in DR programs by showing facility managers a profile of their plant's energy use and working with them to determine DR strategies that can be used without risk of product spoilage or operational disruption.

Because food processors handle diverse products with varied processing requirements and temperature or cooking needs, there is an equally diverse array of activities and equipment in food processing facilities. Therefore, there is no single largest load for the industry; loads are highly dependent on the food and its processing type. In those operations that involve cooling and freezing, this can be the largest electrical load: Some engine rooms for freezers can use up to 10,000 hp, or 7,500 kW.

There are often many small motors used in the conveyance and handling of food within a facility, from off-loading through packaging; together these motors can create significant demand that might be curtailed. Pumps and air compressors can also be larger loads. Lighting is normally not a significant load relative to the process loads in a food processing facility. Those processors involved with cooking and canning food may have significant natural gas usage and their electrical loads may be relatively small. They also must attend to regulatory requirements around cooked food products, so overall they are less suitable DR candidates.

Backup power is often present at food processing facilities to protect against spoilage due to an emergency loss of power. On-site generators can burn natural gas or even fuel oil. However, using generators is more costly than many other options for demand response at a food processing facility, especially pre-cooling and the curtailment of large refrigeration or freezing loads.

One food processing warehouse storing processed fish achieved substantial load reduction in a DR program—230 kW—by turning off its compressors and letting the temperature float in the refrigerated warehouse section of the operation (Figure A-3).

Figure A-3—Demand reduction in a refrigerated food processing warehouse

Human comfort is not a great concern within the food processing industry, but food quality is critical. Particularly in "fresh pack" situations where temperature and airflow might be critical for ripening produce or maintaining food quality, food processors may feel constrained in their energy use. However, testing product temperatures during a "float" reveals that refrigerator and freezer temperatures do not necessarily climb unacceptably during a short curtailment. Thermal mass and industrial-strength insulation of freezers and cooling rooms are key factors that frequently enable food processors to benefit from DR incentives.

Typical DR Strategies for Food Processing

Food processing facilities can successfully contribute to load reductions by using a number of proven strategies. These focus on refrigeration, pre-cooling, lighting, load shifting, and backup generation (Table A-2).

Table A-2—Strategies to reduce demand in food processing

Demand response strategies
Shutting off refrigeration and freezers
Precooling
Shifting processes off peak
Curtailing lighting
Switching to on-site generation

Shutting off refrigeration and freezers. Because success in this industry relies on the quality of the food itself, this strategy may seem counterintuitive. However, in some situations, refrigeration fans, pumps, and compressors can be completely shut down, without pre-cooling the space for several hours—typically the longest DR event—without damaging products. Thermal insulation in walls, ceilings, and floors prevents thawing or temperature creep. Also, the thermal mass of the product itself provides insulation: Even fresh produce with specific temperature requirements above freezing can sustain optimal temperatures for two to three hours. But monitoring equipment is required to ensure that temperatures remain within regulatory requirements, and food processors must be prepared to end curtailment if temperatures rise too rapidly.

Pre-cooling. Food processing facilities that have refrigerated warehouses can shift their load and reduce peak demands by pre-cooling to a lower temperature prior to the DR event, then allowing the temperature to rise naturally. For example, a fish processing facility’s storage warehouse might lower its temperature from 24° to 19.8° Celsius (C) in the morning, and then turn off refrigeration during the afternoon curtailment. The temperature will rise a few degrees and must be monitored to ensure that product quality is not compromised. This facility could also keep fish on ice until after the curtailment period to reduce demand on the refrigeration system.

Shifting processes off-peak. If notice of a DR event is given in advance, some food processing operations can be performed before the curtailment or delayed until after the peak. For example, electric forklifts used for moving pallets of produce or boxed food within a facility should be regularly scheduled for off-peak charging, but a facility that has not made a this a permanent change can incorporate this strategy into its DR program. Other activities—such as bagging fresh produce or packaging frozen foods—can be delayed, particularly if there is already some product prepared to ship.

Curtailing lighting. Food processors may have large HID fixtures in storage areas of their facilities that can be manually dimmed or turned off. Other lighting in unoccupied areas can be curtailed during a DR event.

Switching to on-site generation. Many food processing facilities have on-site backup generation and are good candidates for DR programs that allow the building's load to be shifted onto these generation sources. Switching to backup generation is usually immediate and causes no interruptions to service. However, because backup generation typically consists of diesel generators, local or provincial air-quality regulations may limit this strategy.

How to Get Involved in DR for Food Processing

Contact your local DR provider. Either your utility or a DR provider working on the utility's behalf will meet with you, examine your food processing facility to determine the most appropriate strategies for your situation, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

c. Grocery Stores

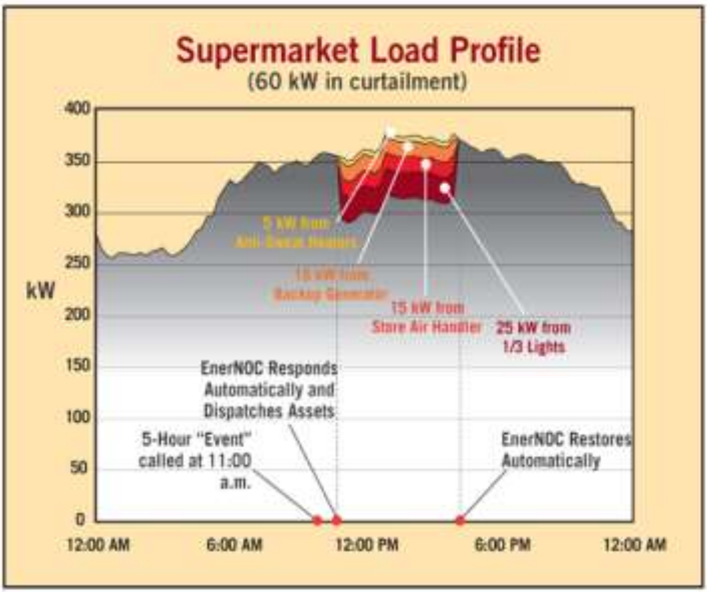
Grocery stores are generally good candidates for DR programs. Chain grocery stores can provide significant aggregate load reductions and incentive revenues, and independent grocers can also create significant load reductions during DR events.

Grocery stores are motivated to participate in DR programs primarily because energy costs remain one of their highest expenses. They can earn financial incentives by shifting load to backup generators, curtailing HVAC and lighting systems, and shutting down refrigeration systems. Additionally, because DR events occur while customers are inside the store, grocery stores can benefit from publicizing their participation. Stores can announce it over the public address system and post signs around the store that explain the social and environmental benefits of the program. They may even boost customer retention by participating in a green initiative.

Grocery stores operate all day and into the late afternoon and evening. Utility peaks tend to occur in the mid-afternoon during the summer months, so grocery stores could be reliable participants in DR programs because their loads, which will be at full capacity during the event, can be curtailed.

The largest electricity users in grocery stores are, in decreasing order: refrigeration, lighting, space cooling, and office equipment. Grocery stores are at a slight disadvantage when participating in DR events compared with other commercial sectors because refrigeration is their largest electric load and they need to maintain proper temperatures to preserve their product. However, grocery stores are able to reduce refrigeration loads by reducing the number of compressor cycles that are run. Additionally, they can reduce HVAC and lighting loads through a BAS. Large grocery stores may also have backup generation systems that facility operators can dispatch, although this is less than 10 percent of all grocery stores in the U.S.

One large supermarket achieved a noticeable load reduction by participating in a DR program. During one DR event, facility operators turned off antisweat heaters, raised thermostat setpoints, turned off one-third of the overhead lights, and dispatched backup generation—and saved 60 kW (Figure A-4).



Note: kW = kilowatt

Courtesy: EnerNOC

Figure A-4—Demand reduction in a supermarket

Depending on local building codes, grocery stores have performance requirements that may limit their DR participation. For example, in some states, grocery stores must monitor ventilation rates to meet indoor-air quality requirements, such as ASHRAE (the American Society of Heating, Refrigerating, and Air-Conditioning Engineers) Standard 62, “Ventilation for Acceptable Indoor Air Quality.” Their refrigeration units must also maintain proper temperatures because their products need to meet health-code and shelf-life requirements. Lastly, grocery stores have to balance the humidity in the store to control condensation: Excess condensation fogs the doors of refrigeration units—preventing customers from seeing products—and can damage refrigeration equipment.

Typical DR Strategies for Grocery Stores

Grocery stores can successfully contribute to load reductions using a number of proven strategies. These focus on lighting, thermostat adjustment, antisweat heaters, refrigeration, load shifting, BASs, and backup generation (Table A-3).

Table A-3—Strategies to reduce demand in grocery stores

Demand response strategy	Overall building demand reduction
Turning off lights	5–8%
Increasing thermostat setpoints	5–10%
Shutting off refrigerated cases	up to 10%
Turning off antisweat heaters	5–10 kilowatts

Turning off lights. Although grocery stores are concerned about lighting their products, they can still use a couple of strategies to reduce lighting loads. First, the store can reduce lighting loads by turning off every other row of lights. Staff can also turn off lighting in special-purpose areas, such as window displays, stockrooms, offices, and other peripheral rooms. These strategies can be conducted either manually or through a BAS. Turning off lights can typically reduce a grocery store's total peak load by 5 to 8 percent. In New York, for example, a grocery store with a total peak load of 375 kW reduced its usage by 30 kW during a DR event by turning off one-third of its lights.

In addition, grocery stores can significantly dim overhead lighting by using dimming ballasts. Studies conducted by the Lighting Research Center at the Rensselaer Polytechnic Institute show that building occupants usually cannot detect lighting level reductions of up to 20 percent. Turning lights off also reduces cooling and refrigeration loads, which can provide cooling and refrigeration demand relief during summer.

Adjusting the thermostat. During a DR event, facility operators can increase thermostat setpoints to decrease cooling demand. Some DR programs offer day-ahead notification of events, allowing facility operators to warn employees that indoor temperatures may be somewhat higher on the day of the event. However, building control designers say that people can tolerate a temperature rise of up to 1.2°C over a four-hour period without feeling inconvenienced—and often without even noticing. Grocery stores can typically reduce their total peak load by 5 percent just by increasing the thermostat setpoint by 1.2°C.

Turning off antisweat heaters. Antisweat heaters are found in glass display doors and refrigerated cases to prevent condensation on the glass (which obstructs product viewing) and ice buildup on door gaskets. The latest antisweat heater controls can sense humidity in the store's ambient air and reduce heater operations in low-humidity conditions. Turning off the antisweat heaters for short periods during a DR event may not cause display cases to fog. Demand savings can range from 5 to 10 kW for a grocery store that has 30,000 to 50,000 square feet of floor space. Note that if antisweat heaters are controlled with humidistats, this strategy will not be applicable in low-humidity climates or in grocery stores with dehumidification systems because the antisweat heaters may already be turned off.

Shutting off refrigerated cases. Store owners are likely to resist this strategy initially. However, in some situations, facility operators can completely shut down refrigeration fans, pumps, and compressors for several hours without damaging products. Thermal insulation in the walls of the refrigeration unit can prevent thawing and temperature creep. Facility operators need to monitor refrigeration equipment to ensure that temperatures remain below regulation levels, and grocery store staff must be prepared to end curtailment if temperatures rise too rapidly. Additionally, staff can shift inventory to empty some of the refrigeration storage units in the back of the store—allowing the store to shut down those empty units.

Shifting processes off peak. Certain processes in a grocery store can be performed before a curtailment event or delayed until after the peak. For example, facility operators can schedule electric forklift charging and food preparation for off-peak hours.

Using a building automation system. A BAS uses sensors and controllers to monitor and optimize temperature, humidity, and lighting levels while minimizing the energy use of fans, pumps, HVAC equipment, lights, and refrigeration equipment. A BAS can be programmed to curtail predetermined loads upon notification from the utility (either day-ahead or early the same day), eliminating the need to manually adjust equipment. Most modern BASs are web-based—meaning that chain grocery stores can have one energy manager control loads in several stores remotely, rather than having one manager at each store. BASs are found in some grocery stores and they can typically reduce total demand by 10 percent. In addition to reducing demand, a BAS that is optimized for energy savings can also reduce a store's overall energy consumption by 5 to 15 percent.

Switching to on-site generation. Some grocery stores have on-site backup generation to keep refrigeration units running during power outages. These customers are good candidates for DR programs that allow shifting building loads onto backup generators. Switching to backup generation is usually immediate, so it causes no interruptions to service. The capacity of backup generators found in grocery stores typically varies from 15 to 25 kW. However, because backup generation typically consists of diesel generators, local or provincial air-quality regulations may limit this strategy.

How to Get Involved in DR for Grocery Stores

Contact your local DR provider. Either your utility or a DR provider working on the utility's behalf will meet with you, examine your facility to determine the most appropriate strategies for your situation, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

d. Hospitals

Hospitals can participate in commercial and industrial (C&I) DR programs without adversely affecting their critical loads, which include medical equipment. Hospitals are generally large facilities offering around-the-clock operations; they have significant load-shedding potential, which makes them reliable candidates for DR programs. Because the hospital industry tends to be underfunded, hospitals are primarily motivated by the financial incentives offered through DR program participation. They can earn incentives by shifting load to their robust backup generators and by cutting back on noncritical loads, such as cafeteria and lounge lighting.

Hospitals are also good candidates because they're required to routinely test their backup generation. Unlike other C&I sectors, hospitals are not afraid to run backup generators during DR events. Testing backup generation typically occurs at night, but once enrolled in a DR program, hospitals can reschedule their tests to coincide with DR events. Hospitals typically have multiple backup generators with large capacities—up to 2 megawatts per generator.

Most healthcare facilities are active 24 hours per day. On hot summer afternoons, hospital cooling loads and lighting systems will be operating at full capacity and will coincide with utility peaks. As a result, a hospital will typically be able to reduce loads by 10 to 15 percent during DR events. This reduction could be even larger if the hospital uses its backup generator to shift loads off the grid.

Hospitals are large buildings with many energy-intensive operations. The largest electricity loads in hospitals are, in decreasing order: lighting, ventilation, and cooling—making lighting and HVAC the best targets for DR. Hospitals often have special-purpose rooms such as cafeterias and lounges in which facility operators can curtail lighting and plug loads without interrupting routine operations. About one-quarter of all hospitals in the U.S. also have a BAS that monitors and controls HVAC and lighting systems. Finally, all hospitals are required to have backup generation, which facility operators could dispatch during events.

A hospital in the northeastern United States achieved a noticeable load reduction by participating in a DR program. On the day of the event, the facility operators increased thermostat setpoints, turned off half of the lights in common areas, shut down escalators, and dispatched backup generation (Figure A-5).

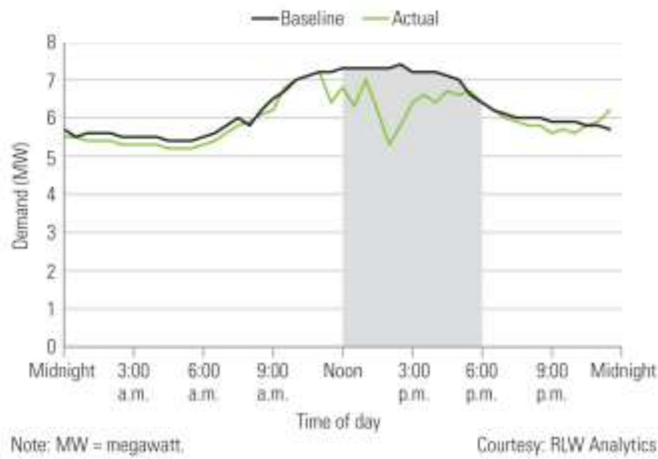


Figure A-5—Demand reduction in a hospital

Hospitals have to pay close attention to indoor-air quality. Their patients may have weakened immune systems, which can make them sensitive to poor air quality. Healthcare employees are also at increased risk of contracting an airborne disease if air quality isn't properly maintained. Hospitals maintain their indoor-air quality primarily by ensuring adequate ventilation and controlling humidity, so they should be conservative when using strategies that could reduce ventilation and increase humidity.

Typical DR Strategies for Hospitals

Hospitals can successfully contribute to load reductions using a number of proven strategies. These focus on lighting, cooling, load shifting, BASs, and backup generation (Table A-4).

Turning off lights. Facility operators can curtail lighting in unoccupied special-purpose rooms such as cafeterias and lounges. Operators can also reduce lighting in corridors. Rooms and corridors can use natural lighting if available. On average, reducing lighting loads in common areas can reduce a building's peak load by up to 5 percent.

Table A-4—Strategies to reduce demand in hospitals

Demand response strategy	Overall building demand reduction (%)
Turning off lights	up to 5
Increasing thermostat setpoints	10–15
Rescheduling kitchen and laundry loads	up to 5

Setting back chillers. Setting the thermostat back can significantly decrease demand for cooling. In many cases, facility operators can raise temperature setpoints on chillers and slow pump systems while still providing adequate cooling. This strategy must be used carefully because other equipment within the chilled-water system may begin to work harder to compensate for the chiller's higher setpoint. Increasing setpoints by 3°C in hospitals can typically reduce overall peak load by 10 to 15 percent.

Shifting loads off peak. Hospitals can shift certain processes to before or after a DR event. For example, facility operators can schedule food preparation, dishwashing, and laundry around an event. This strategy requires that hospital management effectively communicate scheduling requirements to staff so that they don't mistakenly turn these loads on during the event.

Using a building automation system. Many modern healthcare facilities have complex BASs that use sensors and controllers to monitor and optimize lighting, temperature, humidity, and indoor-air quality while minimizing lighting and HVAC energy use. If the BAS can communicate directly with the DR facilitator, the BAS can automatically adjust thermostat setpoints and reduce discretionary lighting loads upon DR notification—eliminating the need to manually adjust equipment. If a hospital doesn't have an automatic DR system, the staff or a facility manager would need to manually switch the BAS into DR mode to reduce HVAC and lighting loads through it.

Switching to on-site generation. All hospitals have large and robust on-site backup generation systems. This equipment makes these customers great candidates for DR programs that allow load shifting using these generation sources. Switching to backup generation is usually immediate, so it causes no interruptions in service. However, because backup generation typically consists of diesel generators, local or provincial air-quality regulations may limit this strategy.

How to Get Involved in DR for Hospitals

Contact your local DR provider. Either your utility or a DR provider working on the utility's behalf will meet with you, examine your facility to determine the most appropriate strategies for your situation, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

e. Hotels and Motels

Hotels and motels are excellent candidates for DR programs because owners (or corporate management, in the case of chains) are striving to “green” their image and improve their position in the marketplace. A greener image can boost profits when hotels advertise their space to event organizers looking for environmentally conscious venues to host their seminars and conferences.

Additionally, because the hotel industry is highly competitive, owners are always looking for ways to reduce operating costs. Incentive payments for participating in a DR program can offset some of these costs and make a positive difference in hotel operations even when there’s no DR event taking place. For example, a DR program can be used to educate staff about simple ways to save money every day, such as turning off lights in guest rooms or closing shades to reduce air-conditioning loads.

Hotels and motels are occupied around the clock. In general, occupancy levels tend to be highest at night. Hotels and motels that have conference rooms or restaurants, on the other hand, can also be highly occupied throughout the day. Regardless of occupancy pattern, hotel electric loads, such as lighting and HVAC, tend to run at full capacity throughout the day—providing multiple opportunities to curtail loads. And because guests are typically not in the hotel in the mid-afternoon, they generally do not notice the effects of load reductions. This gives hotels more flexibility when reducing loads.

Hotels and motels have several large loads that facility operators can curtail during DR events. The largest electricity users in hotels and motels are, in decreasing order: space cooling, lighting, space heating, office equipment, refrigeration, and water heating. As a result, facility operators typically reduce HVAC and lighting loads during curtailment events. Hotels and motels may also shut down kitchen and laundry facilities to reduce water-heating loads. In some larger hotels, swimming pool heaters and pool pumps have large demands and can also be curtailed. Finally, some hotels can shift their loads onto backup generators, depending on local environmental regulations.

One hotel in San Francisco achieved a noticeable load reduction by participating in a DR program. During an event, the hotel's facility manager dimmed or turned off lights in unused areas of the hotel, such as conference rooms, and increased thermostat setpoints by 1.2°C (Figure A-6).

Depending on local building codes, hotels and motels may have mandatory indoor-air quality requirements, such as ASHRAE Standard 62, "Ventilation for Acceptable Indoor Air

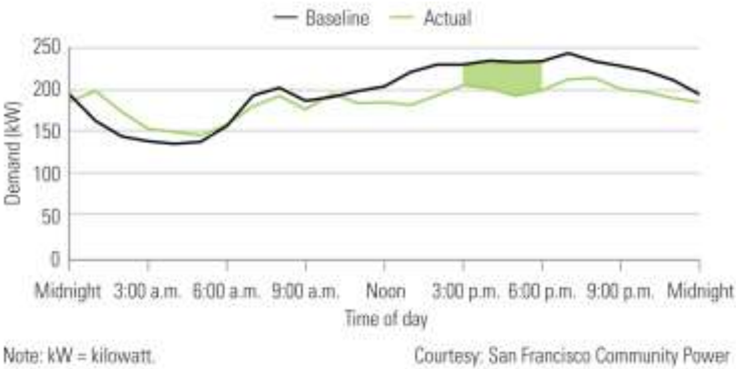


Figure A-6—Demand reduction in a hotel

Quality," which must be considered when enrolling in a DR program. Also, due to the nature of the hospitality business, it can sometimes be difficult to reduce certain loads, especially in guest rooms. However, hotels and motels can still reduce loads by adjusting cooling setpoints and reducing lighting in common areas such as atriums and empty conference and meeting rooms. Also, many hotels and motels have backup generators that can be used to offset the building's load during a DR event.

Typical DR Strategies for Hotels and Motels

Hotels and motels can successfully contribute to load reductions using a number of proven strategies. These focus on lighting, cooling, manual load reduction, elevators and escalators, backup generation, and BASs (Table A-5).

Curtailing lighting. Hotels and motels typically have discretionary lighting loads or decorative lighting in the atrium, conference rooms, and meeting rooms that hotel staff

Table A-5—Strategies to reduce demand in hotels

Demand response strategy	Overall building demand reduction
Turning off lights	up to 5%
Increasing thermostat setpoints	8–10%
Rescheduling kitchen and laundry loads	up to 5%
Turning off fountain pumps	3–10 kW
Shutting down elevators	up to 30 kW
Shutting down escalators	up to 7 kW
Turning off ice machines	1–5 kW

Note: kW = kilowatt.

can turn off during a DR event. Staff can also turn off lighting in unused special-purpose rooms such as restaurants, conference rooms, and exercise facilities. On the morning of a DR event, facility managers can also remind staff to turn off lights in unoccupied areas and guest rooms. On DR event days, the staff can reiterate that policy to the housekeeping staff. Turning off lights can reduce a hotel's total peak load by up to 5 percent.

Reducing air conditioning. Hotel air-conditioning systems are typically running at full capacity throughout the day in summer. During a DR event, facility managers can raise thermostat setpoints to decrease cooling demand. Some DR programs offer day-ahead notification of events, allowing facility operators to warn guests that indoor temperatures may be somewhat higher on the day of the event. Staff can also be reminded in advance to draw the blinds in guest rooms to reduce cooling loads and turn off room air conditioners in unoccupied rooms. Curtailing air-conditioning loads can typically reduce a hotel's total peak load by 8 to 10 percent.

Manually reducing or eliminating key equipment loads. There are a couple of key equipment loads that can be shut down in the mid-afternoon when most guests are not in the hotel. First, hotels can turn settings in the swimming pool, kitchen facilities, and laundry facilities down or off if these systems aren't in use. Kitchen and laundry activities can also be shifted to off-peak times. This strategy requires that management effectively communicate these activities to hotel staff because these loads must be turned off by hand.

Turning off fountain pumps. Interior fountains in some hotels provide aesthetic appeal as well as evaporative cooling. However, shutting down fountains during DR events will not cause much discomfort to the occupants. Potential demand savings vary from 3 to 10 kW for most fountain pumps.

Shutting down elevators and escalators. If a hotel has multiple elevators and escalators, facility managers can shut down a portion of these loads when there is low demand from guests. Generally speaking, shutting down an elevator can reduce demand by 30 kW, while turning off an escalator can reduce demand by 7 kW.

Switching to on-site generation. Some hotels and motels have on-site backup generation. Such customers are good candidates for DR programs that allow the shifting of building loads onto these generation sources. Switching to backup generation is usually immediate, so it causes no interruptions to service. Hotel generators typically have capacities ranging from 250 to 500 kW. However, because backup generation typically consists of diesel generators, local or provincial air-quality regulations may limit this strategy.

Using a building automation system. Although few older facilities have them, many modern hotel and motel facilities have BASs that use sensors and controllers to monitor and optimize lighting, temperature, pressure, humidity, and flow rates—while minimizing lighting and HVAC energy use in common areas (the guest rooms are typically not controlled by the BAS). If the BAS can communicate directly with the DR facilitator, it can automatically adjust thermostat setpoints and reduce discretionary lighting loads upon DR notification—eliminating the need to manually adjust equipment. If a hotel doesn't have an automatic DR system, the staff or a facility manager will need to manually switch the BAS into DR mode whenever a curtailment event occurs.

How to Get Involved in DR for Hotels and Motels

Contact your local DR provider. Either your utility or a DR provider working on the utility's behalf will meet with you, examine your facility to determine the most appropriate strategies for your situation, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

f. Manufacturing Facilities

Given their very large overall electric loads, manufacturing facilities often have the most to gain of any C&I customer from participating in a DR program—and utilities and DR providers have a lot to gain by registering these facilities in a DR program. Many manufacturing plants have flexibility in their operations, allowing them to reap the financial rewards of DR. This may be achieved without impeding production and may even be greeted with enthusiasm by employees at the plant. But for many plants, especially those that have experienced blackouts, grid reliability is still the prime motivator. DR program participation helps keep the lights on in the service territory.

Manufacturing facilities tend to carefully monitor their operations and processes, but not necessarily their energy use. Many facility operators—even those that use a BAS—have never seen a snapshot of their facility's load profile. DR providers or utilities can make a compelling case for manufacturers to participate in DR programs by simply showing facility managers a profile of their plant's energy use.

Activity schedules of manufacturing facilities vary widely, as do the operations that the facilities perform. Some are active 24 hours per day, while others maintain conventional business hours. On summer afternoons, outdoor temperatures may cause a manufacturing facility's peak cooling demand to occur around the same time as its operations peak, both of which may also coincide with utility peaks. This makes manufacturing facilities excellent candidates for demand response because processes can be shifted to off-peak periods.

Manufacturing facilities vary widely in activities and equipment, but process loads—the primary functions of a facility—are the top energy users in nearly every instance. Compressed air is also a large consumer in 70 percent of manufacturing facilities, providing mechanical motion, cooling, pressurization, and other functions for tools, actuators, and robotics. Drive power accounts for a major of portion of the load in some facilities as well. HVAC and lighting systems are next, followed by other equipment such as computers used in plant offices. Battery charging stations may also represent significant loads. Some high-tech manufacturing facilities employ a BAS, and backup generation is likely available where power outages could prove disastrous to the manufacturing process.

One wire manufacturer achieved a noticeable load reduction after performing an energy audit. During a DR event, seven production lines were halted to reduce the facility's demand, bringing the facility's 3.1-megawatt peak load down by 615 kW (Figure A-7, next page).

Occupant comfort is not a top priority in manufacturing facilities; HVAC energy use is usually rather limited when compared with production costs. Spaces are usually conditioned to regulate humidity and temperature to protect sensitive materials or perishable food products. Maintaining production is generally the highest priority, but opportunities exist to reduce demand system-wide without affecting production—especially at times and in processes where facilities may unwittingly be spending a lot on energy.

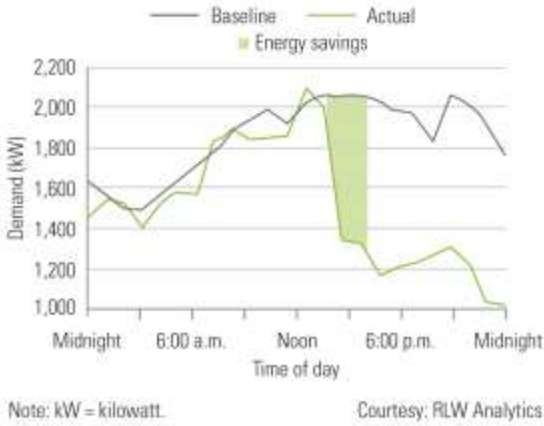


Figure A-7—Demand reduction in a manufacturing facility

Typical DR Strategies for Manufacturing Facilities

Manufacturing facilities can successfully contribute to load reductions using a number of proven strategies. These focus on load shifting, backup generation, lighting, and BASs (Table A-6).

Table A-6—Strategies to reduce demand in manufacturing

Demand response strategy
Moving processes off peak
Switching to on-site generation
Curtailing lighting
Using a building automation system (BAS)

Moving processes off peak. Many manufacturing facilities can schedule processes for off-peak times if given advance notice of a DR event, and others can change schedules with little notice, shifting large loads off-peak. For example, when given advance notice of a DR event, the operator of a cubic zirconia factory, which forms crystals in batches, orders nearly-finished batches to be rushed through production and waits to start the next batch until after the peak. At some stages of the process, the plant's production can even be shut down midway without loss of product—leading to 4 megawatts of overall load reduction during the event. In another example, a metal-scrapping operation powers down equipment and stockpiles scrap for the length of the curtailment, receiving 35 cents per kilowatt-hour dropped per occurrence (in addition to monthly incentives from the utility). Businesses should work closely with their utilities or DR providers to determine which facilities are good candidates for these types of opportunities—many of which may be unfamiliar to facility managers.

Switching to on-site generation. Many manufacturing facilities have on-site backup generation and are good candidates for DR programs that allow the building's load to be shifted onto these generation sources. Switching to backup generation is usually immediate and causes no interruptions to service. However, because backup generation typically consists of diesel generators, local or provincial air-quality regulations may limit this strategy.

Curtailing lighting. Although lighting is one of the smallest loads in most manufacturing facilities, the facilities can still obtain some benefit by manually curtailing or dimming lights that are nonessential or located in unoccupied areas.

Using a building automation system. Found in high-tech manufacturing facilities, a BAS monitors and optimizes temperature, pressure, humidity, and flow rates while minimizing the energy use of fans, pumps, HVAC equipment, dampers, mixing boxes, and thermostats. Upon notification from the utility or DR provider of an event (either day-ahead or early the same day), a facility manager can set the BAS to curtail specific, predetermined loads, thus eliminating the need to manually adjust equipment. Facility staff may need education about how to program the BAS to perform curtailment tasks. The existing BAS may also need a retrofit to translate the DR notification message into the proper subroutine for the end-use equipment.

How to Get Involved in DR for Manufacturing Facilities

Contact your local DR provider. Either your utility or a DR provider working on the utility's behalf will meet with you, examine your facility to determine the most appropriate strategies for your situation, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

g. Mining

Mining operations can have very large electric loads operating during times of peak demand, and they can therefore be excellent candidates for demand response. In particular, mines that are not just extractive but that also have substantial on-site processing facilities will be better positioned to take advantage of DR programs. However, not all mines will find DR incentives meaningful in their overall income stream, or they may not be flexible enough to accommodate curtailment.

Some mines, especially those working in precious metals (such as gold or copper) are unlikely to participate in DR programs. These mines are likely working at maximum output, perhaps even 24 hours per day, due to high demand or high profitability. DR incentives are not as meaningful to them compared with the profitability of extracting more of their product. Other mines may find it more feasible to curtail due to flexibility in their processing operations. In addition, mines that can build up inventory—such as some sand and gravel mines—have flexibility in their need for minerals processing: Because they have market-ready product stored on-site and relatively low profit margins, they can often accommodate load shedding and even complete shutdowns while benefiting from DR incentives.

On-site generation is regularly available at mines, which are often located in more remote areas where the grid may not be stable. Some mining operations start off-grid and are self-sufficient before connecting with the grid. In other cases, mines may handle materials that are part of a critical manufacturing chain that cannot sustain interruption, so they must have emergency on-site generation capacity. Therefore, generators are often an existing resource that could be brought online to displace grid load during a DR event.

Because mining operations are such intensive users of electricity, they are often very aware of their energy use and may already be optimizing their processes for maximum efficiency and lower bills by understanding their overall load profile and managing their peak demand. In addition, because of grid reliability issues that can be part of the mining context, energy management may already be a standard practice at some mines. Some larger operations may also have control systems for their process loads, lighting, and HVAC. However, there may be no dedicated energy manager on staff in many mines.

As with manufacturing, mining operations can vary widely in activities and equipment, depending on what material is mined. However, there are some relatively common types of mining equipment, including rollers, crushers, drills, and pumps. Many types of equipment, such as mills and basic pumps, are small to midsize, in the 200-kW to 400-kW range. Larger facilities may assemble multiple 400-kW mills at their site, for a very large combined load. Other equipment, such as dredge pumps, can be very large, with a demand for power approaching 1 megawatt. The process loads used for any sort of refining or processing of the product on-site are by far the largest energy uses in mining. Slowing these loads down is key to successful demand response.

One mine with on-site minerals processing achieved near-complete load reduction through participation in a DR program. During a two-hour DR event, the facility shut down its crushing and milling equipment, including roller mills, secondary equipment, and compressors, and curtailed nearly 1 megawatt (Figure A-8).

Occupant comfort is not a top priority in mining facilities. Lighting and HVAC are rather small loads when compared with other equipment, and most mining activities occur outdoors, so office activities are limited. Maintaining minerals extraction, sometimes processing material on-site, and filling orders are top priorities in this sector.

Typical DR Strategies for Mining Facilities

Mining operations can successfully contribute to load reductions using a number of proven strategies. These focus on

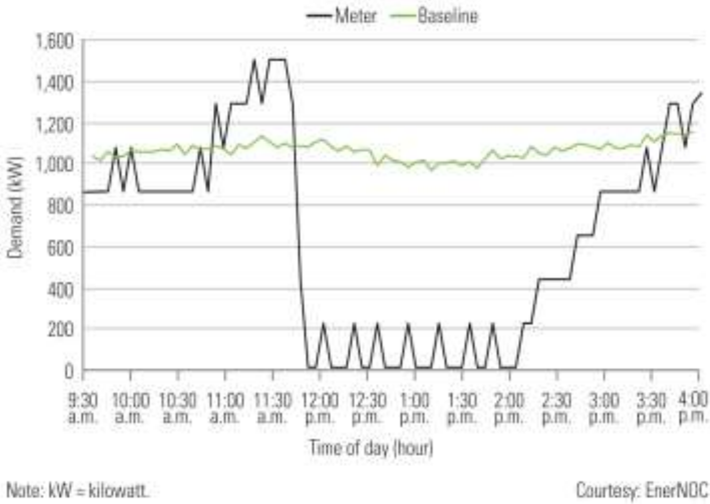


Figure A-8—Demand reduction in a mining operation

load shifting, backup generation, lighting and HVAC, and BASs (Table A-7).

Moving processes off peak. Many mining facilities can schedule processes for earlier or later in the day if given advance notice of a DR event; others can change schedules and shift large loads off peak. For example, when given advance notice of a DR event, an aggregate mining operation producing sand and gravel was able to entirely shut down its extractive processes and equipment, relying on accumulated inventory to fill orders. By shutting down its 1,100-hp dredge pump and 300-hp booster pump, the facility curtailed nearly 1 megawatt of demand.

In some cases, if there is enough inventory and the event is short, load can simply be shed without needing to shift activity to after the peak. Sometimes, processing or extraction (or both) may be slowed down or broken into batches that sequentially use different equipment, rather than being entirely shut down. Manufacturing equipment may also be on-site, meaning that extraction might continue to occur, but crushers or milling machines could be shut down. Each mining operation should work closely with its utility or DR provider to determine

Table A-7—Strategies to reduce demand in mining

Demand response strategies
Moving processes off peak
Switching to on-site generation
Curtailing lighting and HVAC
Using a building automation system (BAS)

whether it is a good candidate for these types of opportunities, many of which may be unfamiliar to facility managers.

Switching to on-site generation. Because mines are often located in remote areas that have less-reliable grid service, many already have emergency backup generation that could displace load during a DR event. Switching to backup generation is usually immediate and causes no interruptions to service. However, because backup generation typically consists of diesel generators, local or provincial air-quality regulations may limit this strategy.

Curtailing lighting and HVAC. Although lighting and HVAC are small loads in the overall profile of mining operations, these businesses can still obtain some benefit by manually curtailing or dimming lights that are nonessential or located in unoccupied areas. Mines can also pre-cool when necessary, then set back or shut down air conditioning.

Control programs or building automation systems. Mines with on-site processing facilities may already have or be good candidates for a BAS or for control systems that extend to on-site buildings and processing equipment. These systems could help automate curtailment or slowdown routines for crushers, pumps, mills, and other equipment; they can also help by dimming lights and setting back HVAC systems for the limited buildings available.

How to Get Involved in DR for Mining

Contact your local DR provider. Either your utility or a DR provider working on the utility's behalf will meet with you, examine your facility to determine the most appropriate strategies for your situation, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

h. Office Buildings

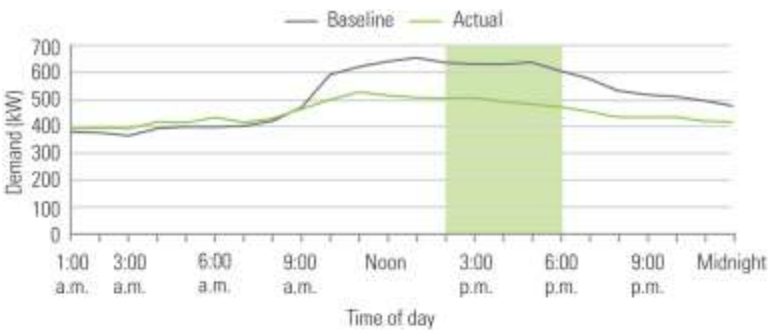
Offices can be good targets for DR programs because building owners often strive for a “green” image to boost market position and continually seek ways to trim ever-increasing energy costs. Some office owners and managers use green measures to reduce operating expenses for their tenants. This makes the space more attractive for leasing and ultimately improves the profitability of all parties involved.

Due to regular operating hours and facility characteristics, office buildings have large loads that can be predictably curtailed, making them good candidates for some DR programs. Offices tend to have the highest occupancy from early morning through late evening. Many have peak demands coincident with utility peaks on summer afternoons, as air conditioning use increases. As a result, it is likely that an office building will be occupied during DR events.

The largest energy users in office buildings are, in decreasing order: space heating, cooling, office equipment, and lighting—making HVAC the best target for demand response. Some buildings have special-purpose rooms, such as cafeterias, auditoriums, and recreational facilities, in which lighting and plug loads can be curtailed without inconvenience. Many modern office buildings have sophisticated building automation systems that control HVAC, lighting, and other systems. A BAS provides a centralized means to control an automated DR strategy throughout a building, which is vital because office buildings do not typically have facility or energy managers on-site to react to DR events.

One San Francisco office building achieved a noticeable load reduction through its participation in a DR program. It dimmed or turned off lights in unused areas and adjusted HVAC settings to reduce demand (Figure A-9).

Office buildings have indoor-air quality and comfort requirements that utilities must consider when recruiting them for participation in a DR program. Because office occupants tend to remain in the same location for relatively long periods of time, they are likely to notice—and be inconvenienced by—changes in the environment. However, within these requirements, office buildings can reduce loads in many ways, such as by adjusting HVAC setpoints, reducing lighting, and turning off plug loads. Some office buildings also have backup generators, which, depending upon local environmental regulations, may be used to offset the building's load during a DR event.



Note: kW = kilowatt.

Courtesy: San Francisco Community Power

Figure A-9—Demand reduction in an office building

Typical DR Strategies for Office Buildings

Office buildings can successfully contribute to load reductions using a number of proven strategies. These focus on thermostat adjustments, reducing fan speeds, pre-cooling, cooling, lighting, manual load reduction, backup generation, and BASs (Table A-8).

Adjusting thermostats. During a DR event, thermostats can be adjusted to decrease electricity demand. Some DR programs offer day-ahead notification of events, allowing facility operators to warn building occupants that indoor temperatures may be somewhat higher on the day of the event. However, control designers claim that people can tolerate a temperature rise of around one or two degrees over a four-hour period without feeling inconvenienced and, in many cases, without even noticing.

Table A-8—Strategies to reduce demand in office buildings

Demand response strategies
Adjusting thermostats
Adjusting chiller setpoints
Decreasing fan speeds
Precooling
Curtailing lighting
Manually reducing or eliminating key equipment loads
Switching to on-site generation
Using a building automation system (BAS)

Adjusting chiller setpoints. The temperature setpoint of the chilled-water system can be adjusted upward to decrease the air-conditioning electricity demand. With this strategy, overall building temperatures will rise slightly, though ventilation systems will remain at their normal level. This strategy must be used carefully because other equipment within the chilled-water system may be forced to work harder to compensate for the chiller's higher setpoint.

Decreasing fan speeds. Office buildings often have ventilation systems with variable-frequency drives, allowing fan speeds to be slowed during DR events. This can be implemented successfully in conjunction with other HVAC strategies such as setpoint adjustments.

Pre-cooling. Office buildings are good candidates for pre-cooling, a strategy in which the building is over-cooled in advance of a DR event—usually overnight or during the early morning. An office building's thermal mass helps store the cooling energy, which is slowly released throughout the day, allowing thermostats to be set higher during the DR event.

Curtailing lighting. During DR events, lighting can be turned off in special-purpose rooms such as cafeterias, auditoriums, and recreational facilities, as well as in selected hallways and other areas. In addition, overhead lights in occupied areas can be selectively turned off, with occupants relying on task lamps if necessary. Office buildings can use dimming ballasts to lower the lights—studies show that building occupants usually cannot detect lighting-level reductions of up to 20 percent. Turning off lights also reduces cooling loads, which can provide demand relief during the summer.

Manually reducing or eliminating key equipment loads. During a DR event, building staff can turn off unused office equipment, vending machines, air handlers, and exterior lighting or signage. This strategy requires a concerted effort on the part of building occupants to meet load reduction goals, so it may not be feasible in all office settings.

Switching to on-site generation. Some office buildings have on-site backup generation. Such customers are good candidates for DR programs that allow the shifting of the building’s load onto these generation sources. Switching to backup generation is usually immediate, so it causes no interruptions in service. However, because backup generation typically consists of diesel generators, local or provincial air-quality regulations may limit this strategy.

Using a building automation system. The majority of modern office buildings have a BAS, which uses sensors and controllers to monitor and optimize temperature, pressure, humidity, and flow rates while minimizing the energy use of fans, pumps, HVAC equipment, dampers, mixing boxes, and thermostats. The BAS is programmed to curtail predetermined loads upon notification (either day-ahead or early the same day) from the utility, independent system operator, or DR provider. One DR strategy that offices can implement using a BAS is global temperature reset. Upon receipt of notification of a DR event, the BAS can adjust the HVAC setpoint temperature either up or down, usually by 1.2° to 4.8°C.

If a building does not have a facility manager, its occupants may need education from its utility or DR provider on how to program the BAS. The existing BAS may need retrofitting to enable communication of curtailment requests from the utility to the BAS then to the end-use equipment.

How to Get Involved in DR for Office Buildings

Contact your local DR provider. Either your utility or a DR provider working on the utility’s behalf will meet with you, examine your facility to determine the most appropriate strategies, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

i. Retail Stores

Retail buildings tend to be reliable C&I participants in DR programs. Chain retail stores, in particular, can provide utilities or DR providers with significant pooled load reduction if a number of stores in the chain participate. Working with a single corporate-wide facility manager can also simplify DR contracts. However, even independent retail stores can provide high curtailment levels by reducing their HVAC and lighting loads.

Because retail customers are likely to notice DR actions in a store—decreased lighting or warmer-than-usual temperatures—program facilitators recommend providing information to customers to help them understand and support the program's social and environmental benefits. Stores can inform their customers of an event by announcing it over the public address system and posting signs around the store that explain the benefits of the program. Many stores even market their participation as a green initiative, which may boost their image with customers and reduce customer complaints.

Incentive payments play a large role in attracting retail stores to participate because they can boost the stores' bottom line. This is especially true if the store is concerned about losing revenue during events.

Retail buildings typically operate all day and into the late afternoon and evening. As a result, retail stores are likely to be able to offer regular benefits by curtailing their loads because many utilities will have a peak in late afternoon in summer.

Also, retail stores are prime targets for DR because the majority of the occupants—visiting customers—will not be in the store for the entire duration of the event. Typically, customers may only be in the store for up to 30 minutes. This differs from other building sectors, where the majority of the occupants are employees who would endure load reductions for several hours.

The largest electricity users in retail stores are, in order of decreasing size: space cooling, lighting, office equipment, and refrigeration—making HVAC and lighting the best targets for demand response. To reduce air-conditioning loads, facility operators can increase the store’s thermostat setpoint by a couple of degrees. In some retail stores, facility operators can tap smaller non-essential loads for curtailing during a DR event, such as vending machines, office computers, and signage. Large retail stores may also have backup generation that the facility operator could dispatch during events (although less than 10 percent of all retail stores in the U.S. have backup generation resources).

For example, an 8,000-square-foot retail store in New York achieved a significant load reduction through participating in a DR program. During the event, the store’s facility operator increased the temperature setpoint by 1.8°C, which reduced the load of the store’s three 6-ton rooftop air-conditioning units. By reducing just its air-conditioning load, the store was able to reduce demand by 4 kW (Figure A-10, next page).

Depending on local building codes, retail stores may have mandatory indoor-air quality requirements, such as ASHRAE Standard 62, “Ventilation for Acceptable Indoor Air Quality,”

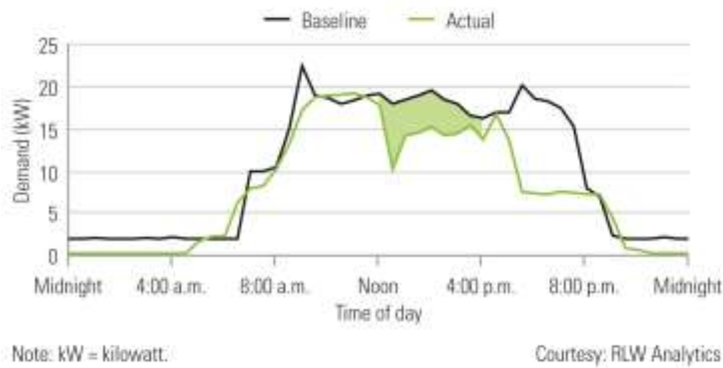


Figure A-10—Demand reduction in a retail store

which may limit participation. If this is the case, facility operators must monitor ventilation rates and follow guidelines when reducing their HVAC loads to avoid air-quality problems. Thermal comfort and proper lighting levels may also keep retail stores from participating fully because they want to minimize the influence on their primary operation: selling goods. Therefore, they always want to be cautious of any potential negative effects load reduction might have on store revenue.

Typical DR Strategies for Retail Stores

Retail stores can successfully provide load reductions by using a few proven strategies. In addition to reducing lighting and HVAC loads, stores can also curtail other equipment loads, make use of a BAS, use pre-cooling, and employ backup generation (Table A-9).

Turning off lights. Although retailers are very concerned about lighting their products, they can still use a couple of strategies to reduce lighting loads. First, they can use natural lighting if products are placed near exterior windows. The store may also turn off a portion of its lights or turn off every other row of lights. Finally, during DR events, store staff can turn lights off (either manually or with a BAS) in special-purpose areas such as window displays, stockrooms, offices, and other peripheral rooms. Turning off lights can reduce overall building demand by 5 to 15 percent.

Retail stores can also use dimming ballasts to dim the lights. Continuous-dimming ballasts can gradually dim fluorescent lamps up to 90 percent without shutting them off. Studies conducted by the Lighting Research Center (associated with the Rensselaer Polytechnic Institute) show that building occupants cannot detect lighting level reductions of up to 20 percent. Turning off lights also reduces cooling loads, which can provide demand relief during the summer.

Table A-9—Strategies to reduce demand in retail stores

Demand response strategy	Overall building demand reduction (%)
Turning off lights	5–15
Increasing thermostat setpoint	5–20
Turning off plug loads (office equipment and vending machines)	up to 5

Reducing HVAC loads. During a DR event, facility operators can adjust thermostat setpoints to decrease electricity demand. Some DR programs offer day-ahead notification of events, allowing facility operators to warn employees that indoor temperatures may be somewhat higher on the day of the event. However, building control designers claim that people can tolerate a temperature rise of up to 1.2°C over a four-hour period without feeling inconvenienced and, in many cases, without even noticing.

Manually reducing or eliminating key equipment loads. During a DR event, facility operators can turn off unused office equipment, vending machines, air handlers, and signage. This strategy requires a concerted effort on the part of employees to meet significant load-reduction goals. Therefore, this strategy may not be feasible in all retail stores.

Programming building automation systems. Although only about 5 percent of all retail buildings in the U.S. have a BAS, most retail buildings larger than 100,000 square feet have them. BASs provide a couple of benefits when participating in DR programs: First, it simplifies the DR implementation for the store because the BAS can be preprogrammed by the facility operator to reduce lighting and HVAC loads. Second, by properly programming the BAS, the corporate headquarters has the peace of mind that the HVAC and lighting loads will be turned back on after the event. Third, the BAS will often have a detailed monitoring functionality that allows facility operators to track demand reductions.

BASs may also be tied to an automated demand response (auto-DR) system, in which the DR facilitator has remote control of building loads, but facility managers may be reluctant to give up control. If a chain has automation systems at multiple locations, it may be possible to manage DR strategies remotely across several stores.

Pre-cooling. Retail stores are good candidates for pre-cooling, a strategy in which the building is over-cooled in advance of a DR event—usually overnight or during the early morning hours. A retail building's thermal mass helps store the cooling energy, which is slowly released throughout the day. As a result, pre-cooling allows thermostats to be set higher during the afternoon DR event.

Switching to on-site generation. A limited number of retail stores have on-site backup generation. These stores are good candidates for DR programs that allow shifting the building's load onto these generation sources. Switching to backup generation is usually immediate, so it causes no interruptions to service. However, because backup generation typically consists of diesel generators, local or provincial air-quality regulations may limit this strategy.

How to Get Involved in DR for Retail Stores

Contact your local DR provider. Either your utility or a DR provider working on the utility's behalf will meet with you, examine your facility to determine the most appropriate strategies for your situation, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

j. Schools

Schools tend to be active, reliable participants in DR programs. A committed high-level point of contact is an important factor in working with schools on demand response, and many utilities and DR providers approach a district-level administrator to encourage district-wide participation. This allows contracting for reductions from the entire district instead of a single school. Thus, although the load that any one school can drop may be on the low end of what other C&I customers can drop (35 to 55 kW per curtailment per school), benefits can be increased significantly if aggregated across a district.

Because students are likely to notice DR events in their schools, program facilitators recommend providing lots of information to help them understand and support the programs' social and environmental benefits. Schools can create educational opportunities for students by enlisting their help in enacting a DR strategy.

Incentive payments lead to increased availability of funds for a school's core mission because principals and administrators seek ways to make the most of tight operating budgets. In the case of private schools, money-saving strategies implemented by administrators are important to parents who pay tuition. At the same time, private schools may have more to spend on upgrades needed for some automation of DR participation.

Schools tend to have the highest occupancy from early morning through mid-afternoon and may be unoccupied or only lightly occupied during summer months. However, after-school events and summer school add unpredictability to this schedule—some schools experience high occupancy during summer months. As a result, some schools will have a high demand during a utility's annual peak (mid-afternoon during summer months) as well as during system peaks throughout the year.

The largest energy uses in schools are, in decreasing order: space heating, lighting, cooling, and office equipment. In most climates, the boiler is typically the largest user of energy in a school. Smaller schools may have several small HVAC units; larger schools may have a central chiller. Kitchen facilities and exterior lighting are other common large end-use systems. In some larger schools, swimming pools are also big consumers. These systems may be tapped for load reduction if they are in operation at the time demand response is needed.

One private K–12 school in the San Francisco Bay Area achieved a noticeable load reduction through participation in a DR program. Lights were dimmed or turned off in unused areas of the school and HVAC settings were adjusted during after-school hours (Figure A-11, next page).

Schools have indoor-air quality and comfort requirements that can affect participation in demand response. Because children have higher breathing and metabolic rates than adults, they are more vulnerable to environmental threats. Ventilation is critical for maintaining indoor-air quality, so schools must be careful when using strategies that could reduce ventilation. Thermal comfort requires moderate temperatures because high temperatures reduce alertness and low temperatures reduce dexterity. Frequently and widely fluctuating temperatures can hinder children's ability to focus, although broader fluctuations tend to be more acceptable with natural ventilation. Finally,

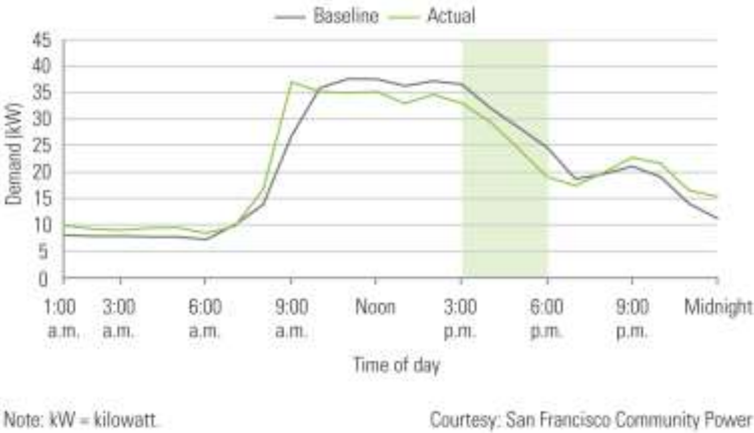


Figure A-11—Demand reduction in a school

visual comfort for the varied tasks within a school—from reading papers on desks to viewing chalkboards or whiteboards—requires adequate amounts of evenly distributed illumination. Within these requirements, schools can allow some temperature setbacks and reduced lighting, as well as some curtailment of plug loads.

Typical DR Strategies for Schools

Schools can successfully contribute to load reductions using a number of proven strategies. These focus on lighting, HVAC, manual load reduction, load shifting, pre-cooling, and BASs (Table A-10, next page).

Table A-10—Strategies to reduce demand in schools

Demand response strategies
Curtailing lighting
Changing HVAC settings
Load shifting with storage
Precooling
Using a building automation system (BAS)

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Curtailing lighting. Lighting in special-purpose rooms such as cafeterias, auditoriums, and recreational facilities can be curtailed when the areas are unoccupied, and lighting in corridors can be selectively reduced. School districts can train custodians or assign students as "energy monitors" to turn off lights in unoccupied areas during DR events.

Changing HVAC settings. Setting thermostats back to minimal settings after school hours (for late-afternoon DR events) works well to decrease demand for cooling or heating. Custodians and students can be trained to adjust thermostats in unoccupied areas during DR events. Also, in many cases, schools can raise temperature setpoints on chillers and reduce pump and fan system speed as much as possible while still providing adequate cooling and ventilation. This strategy must be used carefully because other equipment within the chilled-water system may begin to work harder to compensate for the chiller's higher setpoint. However, this approach requires more work from a facility manager and isn't feasible for schools that lack such a resource.

Manually reducing or eliminating key equipment loads. During a DR event, schools can turn settings on swimming pool pumps and kitchen facilities down or off if these systems are not in use. The same is true for plug loads like computers and other office equipment. This strategy requires a great deal of participation from students and staff because these types of loads generally must be turned off and on by hand.

Load shifting. In schools with air conditioning, cooling is likely to be in use at the time of a DR event. Schools can install thermal ice storage (which creates ice off-peak and circulates fluid through the ice for cooling during the day) to permanently move cooling off-peak.

Pre-cooling. Schools with air conditioning can pursue pre-cooling, in which the facility is over-cooled in advance of a DR event—during the early morning, in most cases. A school's thermal mass then helps store the cooling energy, which is slowly released throughout the day, and temperature settings can be set higher through the afternoon peak. Schools are excellent candidates for this strategy because their thick walls have good thermal mass.

Using a building automation system. BASs are found in schools fairly infrequently; they mostly appear in private or very large schools. They can use sensors and controllers to monitor and optimize temperature, pressure, humidity, and flow rates while minimizing the energy use of loads like fans, pumps, HVAC equipment, dampers, mixing boxes, and thermostats. Schools can program a BAS to curtail specific pre-determined loads upon notification from the utility of a DR event and a subsequent order from a facility manager. This eliminates the need to manually implement the strategies.

Existing BASs may need retrofitting to enable communication with the utility or independent system operator and to facilitate communication from the BAS to the equipment. Finally, schools may install interval metering to monitor load drops during events. If a school district has installed BASs at multiple locations, it may be possible to implement DR strategies from district headquarters.

How to Get Involved in DR for Schools

Contact your local DR provider. Either your utility or a DR provider working on the utility's behalf will meet with you, examine your facility to determine the most appropriate strategies for your situation, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

k. Warehouses

Warehouses can participate in DR programs without adversely affecting their services or internal operations and can often benefit financially. Opportunities to earn incentives by shifting some processes—like refrigeration or forklift charging—off peak or cutting back unnecessary loads can be attractive to warehouse operators. As warehouses have become more service-oriented, their energy consumption has increased and their energy costs now often exceed 10 percent of total revenue. Depending on the size and type of operations, warehouses can reduce their peak loads by 3 percent solely by using lighting strategies, and up to about 30 percent using comprehensive HVAC, refrigeration, lighting, and plug load strategies during DR events.

Warehouses have low levels of human occupancy compared with other C&I facilities. Although the operations of most warehouses are similar, their activity schedules vary widely. Some are active 24 hours per day while others maintain conventional business hours. On summer afternoons, outdoor temperatures may increase a facility's peak cooling demand around the same time as both warehouse operations and utility demand peak.

Approximately half the total energy used in most warehouses comes from electricity, with lighting and HVAC typically being the most energy-intensive systems. (Natural gas consumption for space heating and water heating comprises the other half.) Exceptions include cold-storage warehouses, where refrigeration units often consume the most electricity. Warehouses that use forklifts find that ventilation systems are another large end use. Building automation systems are not generally installed in warehouses.

One warehouse, a 175,000-square-foot bus-storage facility, achieved a noticeable load reduction through its participation in a DR program. It curtailed 54 400-watt metal halide light fixtures and 18 fans, reducing lighting demand by 23.5 kW and fan demand by 128 kW (Figure A-12).

In warehouses, the integrity of goods is more important than comfort. Warehouse owners provide space for customers to store various products or materials and they protect the space from fire and theft. Often the space is equipped to preserve heat-sensitive materials or perishable food products. Performance requirements mostly consist of maintaining adequate temperatures for stored goods, but some warehouses also provide logistics services such as materials pickup,

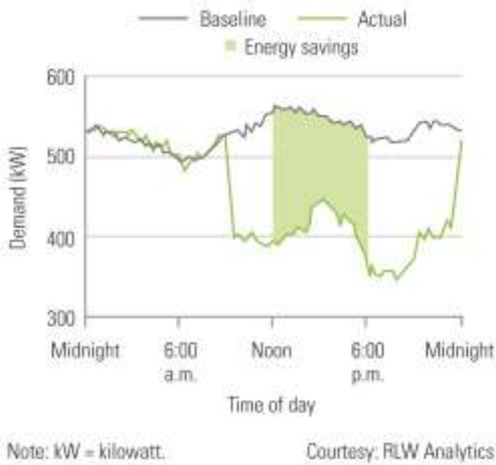

Figure A-12—Demand reduction in a warehouse

computerized inventory control, and materials tracking. These services increase the warehouse's energy demand. Perishable goods may have sensitive temperature requirements, but this does not prohibit refrigerated warehouses from participating in demand response.

Typical DR Strategies for Warehouses

Warehouses can successfully contribute to load reductions using a number of proven strategies. These focus on pre-cooling, lighting, refrigeration, and load shifting (Table A-11).

Pre-cooling. Refrigerated warehouses can shift their load and reduce peak demands by pre-cooling to a lower temperature prior to the DR event, then allowing the temperature to rise naturally. For example, a beverage warehouse could pre-cool during the morning of a DR event and allow the temperature to drift up to its normal setpoint. The cool beverages help serve

Table A-11—Strategies to reduce demand in warehouses

Demand response strategies
Precooling
Curtailing lighting
Shutting off refrigeration
Shifting processes off peak

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as thermal mass to keep the space cool until refrigeration can be restarted.

Curtailing lighting. Warehouses usually have many large HID light fixtures that can be manually dimmed or turned off in unoccupied areas or in areas where full lighting capacity is not necessary during a DR event.

Shutting off refrigeration. Understandably, this strategy is likely to encounter initial resistance from operators. However, in some situations, refrigeration fans, pumps, and compressors can be completely shut down, without pre-cooling the space, for several hours—typically the longest DR event—without damaging products. Thermal insulation in walls, ceilings, and floors prevents thawing or temperature creep. Monitoring equipment is required to ensure that temperatures remain below regulation levels, and warehouse operators must be prepared to end curtailment if temperatures rise too rapidly.

Shifting processes off-peak. If notice of a DR event is given in advance, some warehouse operations can be performed before the curtailment or delayed until after the peak. For example, electric forklift charging should be regularly scheduled for off-peak hours, but a facility that has not made a permanent change can incorporate this strategy into its DR program.

How to Get Involved in DR for Warehouses

Contact your local DR provider. Either your utility or a DR provider working on the utility's behalf will meet with you, examine your facility to determine the most appropriate strategies for your situation, and help you enroll in programs to receive payments or favorable rates for reducing your peak load during events.

Your feedback and comments are appreciated.
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