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Dividends With Demand Response



By Michael Kintner-Meyer, Ph.D., Member ASHRAE, Charles Goldman, Osman Sezgen, and Donna Pratt

A new wave of demand response (DR) programs offers commercial facilities the opportunity to earn money by managing electrical loads in response to market prices. The DR programs are offered by independent system operators (ISOs), which are entities that operate transmission grids, preserve system reliability, and operate spot market auctions where buyers and sellers can meet to complete their obligations. Programs are designed to integrate load curtailments directly into system operations. ISOs typically pay participants amounts equivalent to what generators are paid for equivalent services.

Some programs resemble legacy utility load management programs, where participants receive an upfront option payment for agreeing to curtail load when asked by the ISO. Others are a variation of the real-time pricing (RTP) programs offered by some utilities. In some cases, ISOs are offering programs that provide unique opportunities to receive market prices for load curtailments. *Table*

1 lists various ISO markets and/or services and the typical features of demand response programs in that market. We have categorized DR programs into five basic types with examples of current ISO programs.

Customer's ability and cost to participate in ISO DR programs is influenced by specific program features (e.g., notice, duration and frequency of curtailment, penalties for nonperformance, and payments).[†] The installed capacity (ICAP),

[†] Unlike legacy load management programs provided by regulated utilities, ISO program participation is often distinct from the customer's retail service. In some cases, a customer can take commodity service from one entity, get basic network services from the local utility, and participate in the DR program through a third entity.

Feature	Function of DR in ISO Markets				
	Emergency	Day Ahead Electricity	ICAP	Ancillary Services	Balancing
Notice	Two Hours	Prior Afternoon	Two Hours or Less	Five to 30 Minutes	Hours to Minutes
Duration	Four or More Hours	As Bid by Customer and Scheduled by ISO	Two or More Hours	As Bid by Customer and Dispatched by ISO	One to Eight Hours
Frequency	As Dispatched by ISO		Unlimited, Most Likely In Summer Months		Self-Dispatched When Available
Reservation Payment	None	None	Yes (Six Month Market Value)	Yes (Daily Markets)	None
Performance Payment	Yes	Yes	In Some Cases	Yes	Yes
Example Value	\$0.50/kWh	\$0.05 – \$0.99/kWh	\$0.05 – \$0.50/kWh	\$0.01 – \$0.99/kWh	\$0.01 – \$0.50/kWh
Penalty	None	Market Price	Cash and Participant Privilege Penalties	Market Price	None
Reference	NYISO EDRP	NYISO DADRP	NYISO ICAP 2002	CAISO & ISO-NE Class I	ERCOT, Load as a Resource

Table 1: Independent system operators offer programs for unique load management opportunities.

ancillary services, and emergency resources programs treat DR resources as capacity that is *dispatched* by the ISO system operator to meet system needs. ICAP and emergency DR are generally deployed on two-hours notice in emergency situations, when generator capacity to maintain reserves is not available.‡ Ancillary services are scheduled by the ISO a day ahead and called upon as needed on short notice, usually less than 30 minutes. DR resources can also supply the system's energy needs when the price is right for the participant. Customers or load aggregators can bid load curtailments into the day-ahead market and if the price is lower than a competing generation bid, the curtailment is scheduled by the ISO. The customer submits a bid for the next day, which includes a load reduction quantity at a specified price during specific time periods and receives an acceptance or rejection from the ISO by about noon. The balancing market operates in near real-time. Customers can elect to reduce their usage in response to the level and trend of prevailing prices and are paid the final market-clearing price in the real-time energy market.

Table 1 provides examples of the financial rewards that are attainable under various types of DR programs. The ICAP program provides up-front payments (called reservation or capacity payment), which facilitates financing or funding costs associated with preparing to meet the curtailment obligation. Some ISO ICAP programs also provide for an additional payment for the energy delivered when a curtailment is called. However, non-compliance penalties can consume all of the upfront payment, and result in the habitually noncompliant customer having to pay the ISO money to settle the account at the end of the term.

Conversely, ISO emergency resources programs often do not

penalize customers who fail to curtail load in response to ISO requests. However, there is also no guarantee that load curtailments will be called. The ISO programs that require customers to bid into ISO markets (i.e., the day-ahead and ancillary services market) provide customers with greater control. Customers offer their price, quantity, and time to curtail load. Customers avoid unwanted exposure to penalties when they cannot curtail by not submitting a bid. However, the benefits earned depend on prevailing market prices, and the customer's availability to curtail when prices are high.

How to Assess DR Capabilities?

How should customers determine whether or not to participate and select the best program for their facilities, given the multiple programs offered by an ISO? Based on our research into participation in DR programs, we recommend that facility and energy managers first conduct a systematic assessment of their load curtailment capability and develop a supply curve that characterizes the price at which they are willing to curtail at various compensation rates (Figure 1). Since DR program events are most likely to occur during summer afternoons, the process should be conducted for that period, at least initially.

Facility managers should compile an inventory of electric usage, equipment and devices. Those that cannot operate independently should be considered as an equipment cluster. Next, the items in the inventory are characterized by whether or not they potentially can be curtailed. Electrical equipment, devices or end use loads that are potentially curtailable are grouped by type of services provided. *Discretionary* services

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‡ In the blackout of August 14, 2003 in the Northeast of the U.S., the New York ISO invoked the ICAP and emergency DR programs for the restoration of the New York State power grid. Because of the narrow window of time prior and during the cascading events that led to the blackout, there was insufficient time to invoke the ICAP and emergency DR programs in advance of the system failure.

are those that the facility could do without for a short period of time. More than 25% of DR program participants report turning off banks of lights or reducing HVAC operation.¹ Flexible usage is associated with routine facility operation or services that can be shifted to another time period (e.g., the same day or another day). Examples include recharging batteries, cleaning and maintenance activities, or rescheduling work shifts on event days. Some facilities can use intermediate product or process storage to reduce usage during an event without actually reducing the facility's output or services. For example, many paper processing and cement plants report building up electricity intensive feedstock that is drawn down during curtailment events. Wastewater treatment plants store the water to be treated for later processing. Finally, customers with properly configured on-site generation can use its output to effect a virtual curtailment.

Next, the curtailable electricity uses are categorized by how much time is required to accomplish their curtailment to align load reduction capability with ISO program notice provisions (Step 3 in Figure 1). Those electric uses that require a day's advance planning are separated from those uses/equipment that can be curtailed on the same day with varying amounts of notice (e.g., ranging from 10 minutes to two hours).^{*} For programs that require very short notice (i.e., 10 to 30 minutes), ISOs often require more expensive metering, more frequent communications, and in some cases, cycling requirements for short time periods (e.g., less than an hour). If these additional provisions are difficult for customers, the electric use should be moved to a category with more notice.

The final step involves representing the facility's load curtailment capability in the form of a supply curve (Step 4 in Figure 1). This is accomplished by assigning costs for curtailing various types of identified usage elements or equipment clusters in each notice category, and then stacking the elements from lowest to highest curtailment cost. Establishing cost bins will simplify this process. For example, it makes sense to create low, medium

and high cost bins (e.g., set at \$0.25/kWh, \$0.50/kWh and \$0.75/kWh, respectively) and sort usage elements and equipment clusters that can be curtailed into these cost curtailment bins.

How do you estimate costs of curtailing various types of usage elements or equipment clusters and other impacts on the facility? Curtailing discretionary usage involves direct costs such as labor or other costs associated with shutting equipment

down. Facility managers must also value any potential inconvenience to building occupants from reduced services or amenities, which is harder to quantify. Customers that can curtail flexible usage must recover the costs associated with that shift (e.g., additional labor costs, paying overtime, or added materials and process costs). Storage is possible only by making investments in holding facilities for process feedstock, the amortized cost of which must be recovered, at least in part, from curtailment payments. Operating on-site generation incurs fuel and operation and maintenance costs.

Figure 2 provides a stylized example of the results of this load curtailment assessment process. The curtailment supply curve is interpreted as follows. On the horizontal axis, the first block of load is considered firm and non-curtaillable. The remaining load represents the supply of curtailable load that is available at different curtailment prices, up to the maximum usage, represented by the customer baseline (CBL). The points on the vertical axis represent curtailment threshold prices (CTP). The facility would require a low curtailment price (CTP_L) to curtail the amount represented by the first load curtailment supply block (CS_L). Subsequent blocks (CS_M and CS_H) are available, but at higher payment levels (CTP_M and CTP_H). The curtailment supply curve of Figure 2 furnishes the basis for the development of a bidding strategy by the customer. The curtailment supply curve represents the customer's cost of curtailment. The bid curve is fundamen-

tally the customer's cost of curtailment. The bid curve is fundamen-

^{*}In assessing time required for electric uses/equipment to curtail, customers should create categories that are consistent with their ISO's specific notice requirements.

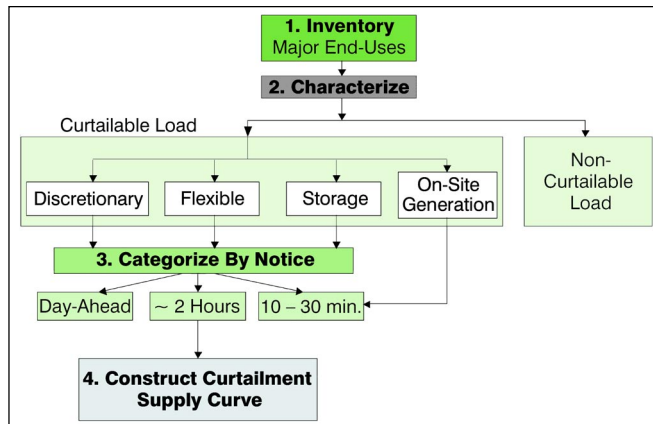


Figure 1: Process to develop supply curve of curtailment capability.

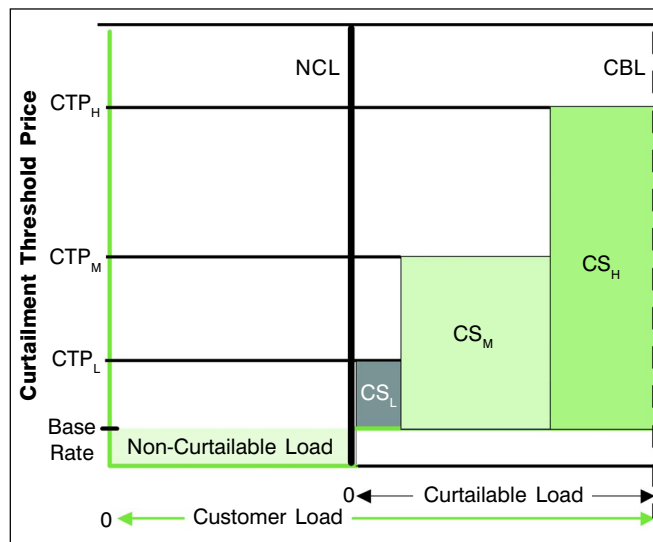


Figure 2: Generic facility curtailment supply curve.

End-Use Inventory		Load Reduction Capabilities			Labor Hours	Cost	
		Discretionary		Self-Supply		Labor for Load Reduction/Fuel Cost	Cost (\$/kWh)
HVAC	1,000 kW	Reset Thermostat	60 kW		2	\$120	0.40
Lighting	900 kW	Dim Lighting at Perimeter	90 kW		2	\$120	0.27
Escalators, Elevators	270 kW	Shut Off Escalators	100 kW		1	\$60	0.11
Office Equipment/Other	850 kW						
Emergency Generator	450 kW			450 kW	1	\$60 plus \$0.12/kWh For Fuel	0.15
Total (Load)	3,000 kW		250 kW				
Total (Gen.)				450 kW			
Total (Load+Gen.)			700 kW				

Table 2: Inventory and characteristics of demand responsiveness for hypothetical building.

tally composed of the curtailment supply curve plus a profit or other bidding constraints that the ISO may impose. For instance, a bid curve with a 10% profit margin would elevate the price thresholds by 10% for the same load reduction amount.

We recommend that customers test their load curtailment strategy before committing to a DR program that has penalty clauses for non- or partial performance. Some ISO programs require customers to demonstrate that their subscribed or claimed load curtailments can be achieved.

Potential Benefits from DR Programs

To illustrate this load curtailment assessment process and the potential benefits of customers participating in ISO DR programs, we consider a hypothetical commercial building in New York City with a summer daytime peak demand of 3 MW and is considering enrolling in the New York Independent System Operator (NYISO) DR programs. In this example, we consider only usage in the discretionary and on-site generation categories. The facility manager estimates that he has 700 kW of load curtailment capability, about 23% of summer peak demand, comprised of 250 kW of discretionary load and 450 kW of self supply (Table 2). The costs for executing individual curtailment strategies include labor estimates to manually turn off equipment, monitor load curtailment performance and restore the load after the event. We estimated a labor rate of \$60/hour. To evaluate the benefits of curtailing, we assumed a five-hour curtailment period (from noon to 5 p.m.) that is coincident with highest electric demand period for the building. Table 2 shows total cost of each measure as well as the cost per energy unit curtailed over the five-hour event. Costs for individual load reduction strategies range between \$0.11 and \$0.40 per kWh. Other impacts on the facility such as valuing any reduction in service or amenity levels, which are more difficult to quantify, are not included.

Figure 3 illustrates the supply curve of selected load reduction measures inventoried in Table 2.

Given the results of the load reduction assessment, it ap-

pears to be cost effective for the hypothetical facility to participate in three DR programs: ICAP, day-ahead market and emergency resources.[§]

To estimate the potential benefits, we examine two scenarios: (1) manually executing and monitoring the measures and restoring the load after the event, and (2) a scenario in which the customer invests and upgrades the facility's energy management and control system (EMCS). The EMCS upgrade reduces the cost of dispatching load reductions by enabling the facility operator to remotely trigger and monitor the load reduction, and to restore the load after the event. To improve the flexibility and cost effectiveness of the automated load reduction dispatch, we estimated that it would cost about \$32,000 for automation that included the installed cost for lighting and HVAC controls, and remote controls for the escalators. Additional controls for the emergency generator would cost \$68,000. We assume that the customer has an interval meter that is sufficient for settlement and billing with the ISO. The future revenue estimates are based on price data from NYISO markets for the summer of 2001.[†]

The day-ahead market program requires customers (or load aggregators) to develop a bidding strategy based on curtailment availability, costs, and the likelihood of being scheduled given their forecast of day-ahead electricity market prices. For our example, the facility decides to bid curtailments at its curtailment cost for a five-hour time block (noon to 5 p.m.). Customers can bundle measures together and bid shorter time blocks (e.g., two hours), particularly if the inconvenience to the occupants is a significant concern, but that influences the revenue potential. In our example, at a bid price at \$0.05/kWh

[§] The emergency program benefits are not estimated in the following example because they are influenced by factors other than price. Because of the expensive telemetry requirements and the very short notification for the ancillary services and balancing, these two programs also are not considered in our example.

[†] NYISO price data for 2001 are available at: www.nyiso.com/markets/index.html.

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