The Power of Demand

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ABSTRACT

Electrical demand management is a strategy used by utility companies to manage peak consumption. For commercial customers, utility companies often include electric demand charges for the maximum power used during a specified time period, measured in $/kW. This is in addition to the charge for power consumed measured in $/kWh. Rate structures generally vary by region and utility company, but the premise is the same. Strategies designed to avoid or minimize the impact of electric demand to reduce operating cost are not a new idea; however, these designs are used primarily in facilities that are large power users where the operation of energy consuming systems can be scheduled to take advantage of the rate structure.

The energy performance of a building is dependent on choices made by the occupants about the proper use and maintenance of building systems. Thus, controlling and adjusting occupant behavior is important to ensuring the full potential of high performance facilities. Traditionally, the design team's role on a project ends when the building is built and all of the post-construction documentation is provided to the owner. Systems in modern-day buildings are complex, especially for users who lack training in architecture or engineering. These misunderstood systems are often incorrectly altered which ultimately impacts building energy consumption. Design, commissioning, and energy professionals can positively impact building performance by training the building occupants on how their systems work.

The techniques for demand avoidance described in this article are so subtle that occupants rarely detect the changes. In this article, actual data and case studies are presented from educational facilities showing the cost of implementation and the return on investment (ROI). The ROI for these system improvements is commonly less than two years.

INTRODUCTION

Achieving energy efficiency that results in reduced operating costs is a top priority for designers, owners, and operators working in the built environment. The many strategies that address energy consumption include more efficient equipment with strict operating schedules and improving building energy performance by managing electric demand – though the latter is often overlooked.

Electric utility charges vary by the service provider, but all generally have three components: electrical consumption, electric demand and tax surcharges. Electric rate structures for consumption vary throughout the United States and prices are commonly higher in coastal locations. Electric demand rate structures also vary in form and complexity, but tend to have greater impacts on the cost of energy for commercial power users. It is not uncommon for the cost of electrical demand to be half of the total electrical cost for a facility in many regions of the U.S.

The idea of reducing operating cost by inventing strategies to minimize electric demand charges is not new. There are numerous examples of solutions including using ice/chilled water storage, distributed power generation and other strategies. Many of these solutions can be costly. Obtaining a justifiable return on investment can be difficult for many project owners.

The use of batteries for storage to manage electric demand is gaining popularity in the United States as the technology matures. This strategy shows promise for buildings, but there are other simpler, low/no cost strategies available to manage electric demand.

SUCCESSFUL DEMAND AVOIDANCE STRATEGIES

A simple design strategy for an easy implementation for electric demand avoidance requires a few pieces of information to verify applicability. The first step is to understand the power use profile by performing an energy benchmark assessment during the last 18-24 months of operation. The benchmark should include consumption, demand and costs. Next, weather data must be collected so that the energy data can be normalized for a reasonable comparison of the results.

A building automation system (BAS) that controls equipment and lighting systems is necessary to implement the process. Finally, a whole building meter integrated into the BAS that measures electrical consumption and demand is essential.

Figure 1 shows a peak demand profile. The electrical demand peak is recognized as the facility recovers from evening set-back temperatures. This pattern is common for facilities with low occupant densities. The maximum demand peaks can occur throughout the day depending on weather and electrical use patterns. The electric demand profile for a facility is generally consistent as long as the pattern of use is uniform.

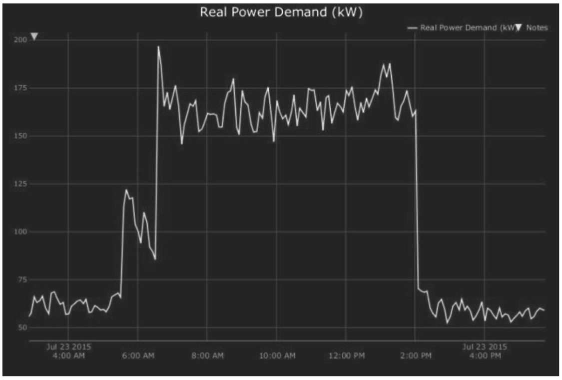

Figure 1. Common electric demand profile.

The electric demand that is of interest is identified by the short duration time period, less than 30 minutes, and has a value 25-40% greater than the regular use value. The following is a summary of recommendations for implementing a demand avoidance strategy in commercial building:

1. *Review building parameter and utility rate structure*. The demand avoidance strategies are most effective for buildings where 80% or greater of its energy needs come from electricity.
2. *Determine the peak demand pattern and target reduction*. Start with a 30% reduction target. Reduction targets may vary according specific demand periods.
3. *Identify the management strategy*. The strategy selected is usually specific to the system design, BAS equipment, and use patterns. Commonly, the systems targeted for management are heating, ventilation, air conditioning (HVAC) and lighting.
4. *Implementation*. A successful strategy includes phases and is struc-

tured to be undetectable by the occupants.

5. *Follow-up*. There are occasions when the implementation strategy misses the target. It is important to remain engaged with the facility management team to monitor operation of the building performance.

A 48,400 SF (4,497 m^2) elementary school in the Kansas City, Missouri metropolitan area was studied to validate this idea. The building was originally constructed in 1966. The building's energy source is 100% electric. HVAC and BAS renovation was completed in August 2012. The electric demand sequence was implemented in July 2014. The cost to implement the electric demand reduction sequence totaled $6,975.

The first step in the process was to study the unregulated electric demand values and develop reasonable limits. Table 1 shows how the demand values compare for this case study. The all-electric nature of this building and its climate suggests that the biggest opportunity for savings comes in the winter months.

Table 1. Maximum demand limits.

Month	Unmanaged Demand (kW)	Max Demand Limit (kW)
Jan	450	325
Feb	413	325
Mar	446	300
April	446	275
May	318	225
June	184	185
July	235	185
Aug	214	215
Sept	214	215
Oct	264	200
Nov	246	250
Dec	472	325

Next, the strategy for managing the demand must be determined. The demand avoidance strategy should occur automatically for effective operation, typically by the BAS. The scope of the BAS at this facility was limited to operation of the HVAC equipment. Therefore, a sequence that adjusted the space temperature set-point using a phased approach was developed as the method for managing the demand.

The utility information and actual weather data was collected for evaluation. The weather information was used to normalize the data allowing the energy consumption and costs to be fairly evaluated. Utility rate structures, fees, and taxes often change. For the case study, the utility rate structure did not change. Table 2 summarizes the normalized energy usages and costs for this evaluation period.

Table 2. Consumption and cost comparison.

Fiscal Year (July to June)	Consumption (kWhr)	Cost
2013/2014	830,720	$ 87,660
2014/2015	721,731	$ 82,678
Difference	-13%	$ 4,981
Data normalized for differences in weather		

Finally, demand avoidance strategies like this occasionally impact the comfort of occupants. A key step in this process is checking with the occupants to verify that the important goal of making this strategy undetectable to building users has been achieved.

CONCLUSIONS

The notion of human impact should be considered in any conversation regarding energy efficiency in the built environment. Occupant behavior and perception are important for the success of demand avoidance strategies.

Traditionally, the design team's role on a project ends when the building is built and all of the post-construction documentation is turned over to the owner. Today, the emphasis on high-performance buildings is allowing design teams to become more engaged in post-occupancy activities such as user training, energy benchmarking and operational feedback.

Systems in modern-day buildings are complex, especially for users who lack training in engineering or energy management. Systems that are not understood by facility managers or users are often altered by occupants to the detriment of comfort, efficiency and operating costs. This leads to frustration by facility managers and occupants, resulting in poor energy performance.

The next step that design professionals can take to positively impact building energy performance is to train both facility managers and occupants about how their systems work. This training is not about how to replace an air filter or perform other routine maintenance. Rather, it should train users how to successfully use the building's spaces and how the demand control sequences may affect them.

This study suggests that electric demand avoidance can be applied in a simple, low cost manner to common building types and yield attractive results. The case study referenced a modest investment of $6,975 that resulted in a simple payback of 16 months. An unlucky discovery during construction caused a $2,000 cost increase for an additional power meter; otherwise the payback would have been 12 months. Further, this strategy is applicable to most areas of the United States, especially for facilities where the cost of demand is at least half of the electrical utility cost.

ABOUT THE AUTHOR

Rod Oathout, PE, CEM, LEED AP, has more than 20 years of experience in engineering design, and is currently a regional engineering leader for DLR Group. Rod is an advocate for integrated design solutions that bring together diverse teams of architects, engineers, and energy professionals to create exceptional projects for DLR Group's clients. Rod has a passion for energy conservation and renewable energy systems. He has contributed to several publications and has presented to regional and national audiences on energy reduction strategies, including the World Energy Engineering Congress in 2013. Rod is a Professional Engineer, Certified Energy Manager and a member of Association of Energy Engineers (AEE). Rod was named a "Legend in Energy" in 2014 by AEE. Contact: roathout@dlrgroup.com; 913-897-7811