WHITE PAPER:

THE FREE LUNCH ALGORITHM

BY TOM ARNOLD

Changes in energy pricing and advances in building controls will nurture the expansion of demand management and deliver significant savings to energy users.

Until recently, demand charges have been overlooked on bills. Many facilities professionals have focused on reducing their costs by cutting kilowatt-hours (kWh) consumption, but now that managers can reduce the demand charge, that mindset is changing. This article will present a summary of the challenges and a unique "Free Lunch" algorithm designed to lower utility demand charges in buildings with control systems.

What are demand charges?

Commercial energy users pay a two-part tariff for energy based on consumption and demand. Consumption is calculated as a per unit charge for all the electricity used during the billing period. The demand portion of the bill is paying for the portion of utility costs based on the maximum usage. A pipe analogy will help — think of consumption, measured in kWh, as what flows the through the energy pipe, and demand, measured in kilowatts (kW), as the size (or diameter) of the energy pipe.

A combination of electric market structures, cost allocation methodologies and the integration of renewable power are shifting more and more costs into demand components of commercial energy bills. In California, typical demand charges account for over 30 percent of a commercial office bill. This is not just a blue-state phenomenon: similar percentages crop up in a wide variety of energy markets as shown in Table 1.

Despite advances in metering technology, demand is typically measured (and billed) by the maximum kW reading in a 15-minute period during the billing month. This maximum demand, typically experienced on a hot day, or heavy use day, is multiplied by the demand charge and shown in some level of detail on the electricity bill with varying degrees of transparency. The implication: one 15-minute spike in demand can send the utility budget sideways for a month and hide other successful conservation efforts.

Utilities have used demand charges for over 100 years, but unfortunately recent rates have escalated to unprecedented levels. California's Pacific Gas & Electric has increased the summer demand charge from $16 to $26 over 10 years, including a budget-busting 25 percent increase in the last year alone (see Figure 1). These changes are occurring even in an environment of falling natural gas prices, and charges could escalate even faster if natural gas returns to long-term price levels.

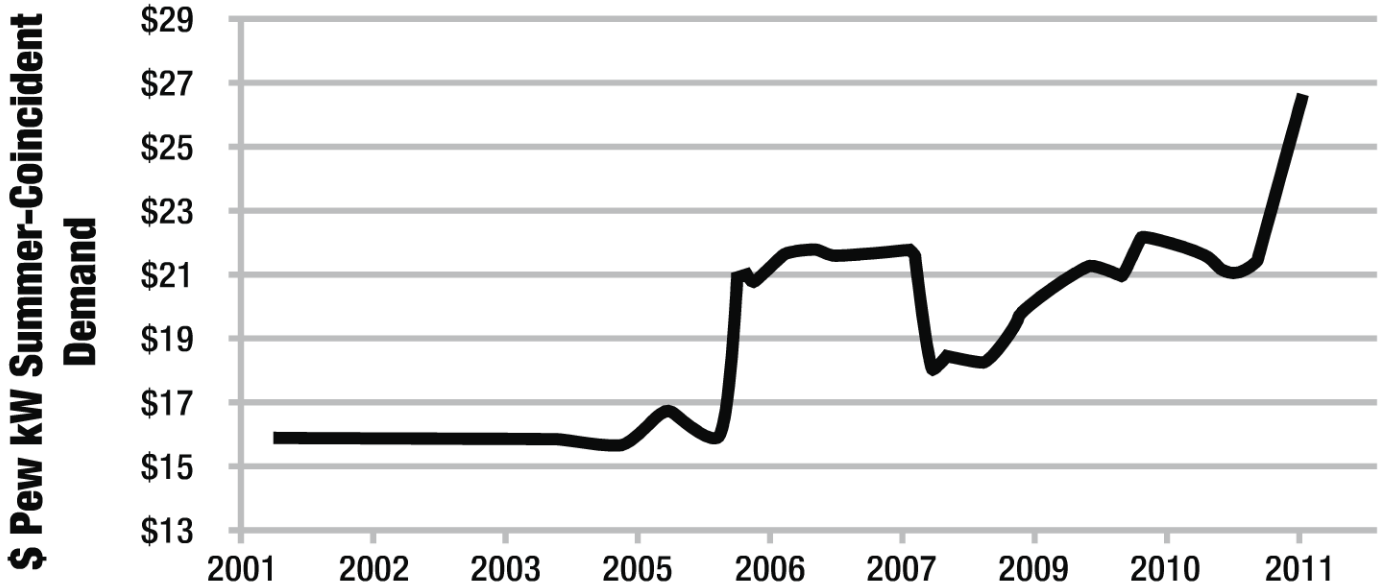
TABLE 1: Sample demand charges ($/kW/Mo) and percentage of total bill for a typical office building for 10 large investor-owned utilities. Source: Gridium Research

	DEMAND CHARGE	DEMAND % OF BILL
Georgia Power	$16.90	82%
FP&L	$6.50	56%
ConEd	$18.00	42%
PG&E	$18.50	34%
SCE	$17.50	30%
PSEG	$13.87	30%
Progress Energy Florida	$4.89	29%
Duke Energy Indiana	$4.00	24%
Dominion	$4.79	22%
Alabama Power	$4.19	21%
ComEd	$5.38	20%

What can be done: enter active energy management

The facility profession has demonstrated an incredible ability to manage demand in a variety of utility and grid-operator-sponsored demand response programs over the last 10 years. Typically compensated by a payment or rebate, demand response programs pay commercial and industrial consumers to reduce demand on a handful of days when the electricity grid is particu-

FIGURE 1: PG&E Summer Demand (Office Profile)



larly strained. Current estimates from the Federal Energy Regulatory Commission (FERC) indicate that over 200,000 facilities in the United States participate in one or more demand response programs, contributing to 21 gigawatt (GW) of peak load reduction — almost 10 times the total solar capacity installed in 2011.

Progressive facility managers are now leveraging these techniques deployed for demand response events to reduce their demand charges. Since the demand charge is set on the highest use day of a billing month, a manager can make a small change to operations and reap the benefits of lower electricity bills. The compensation is ample (typically two to three times the value of demand response payments). Additionally, demand management provides savings year round.

Case Study: Echelon campus in San Jose, CA

A demand management program was implemented by the building staff at the Echelon corporate headquarters campus in San Jose, CA. The Echelon campus consists of two 75,000-square-foot buildings and an open-air parking garage. Ten years of active energy management programs have held total annual electricity cost increases to less than 3 percent, well below utility rate increases. Building staff determined that demand charges now represent 33 percent of the total electricity bill and decided to investigate.

The Echelon buildings are highly weather sensitive and very susceptible to exterior conditions like outside air temperature and thermal load. Fortunately, extensive LonWorks building controls (Echelon is the inventor of the LonWorks protocol) allow facilities staff to fine-tune building systems and reduce costs. The campus has a long history of participation in utility price response and demand response programs, and consequently, good working knowledge of methods to curtail and limit demand without unduly affecting occupant comfort.

San Jose's climate is subject to periodic warming trends, meaning that only a few days in a billing cycle need to be con-

FIGURE 2: Free Lunch Algorithm

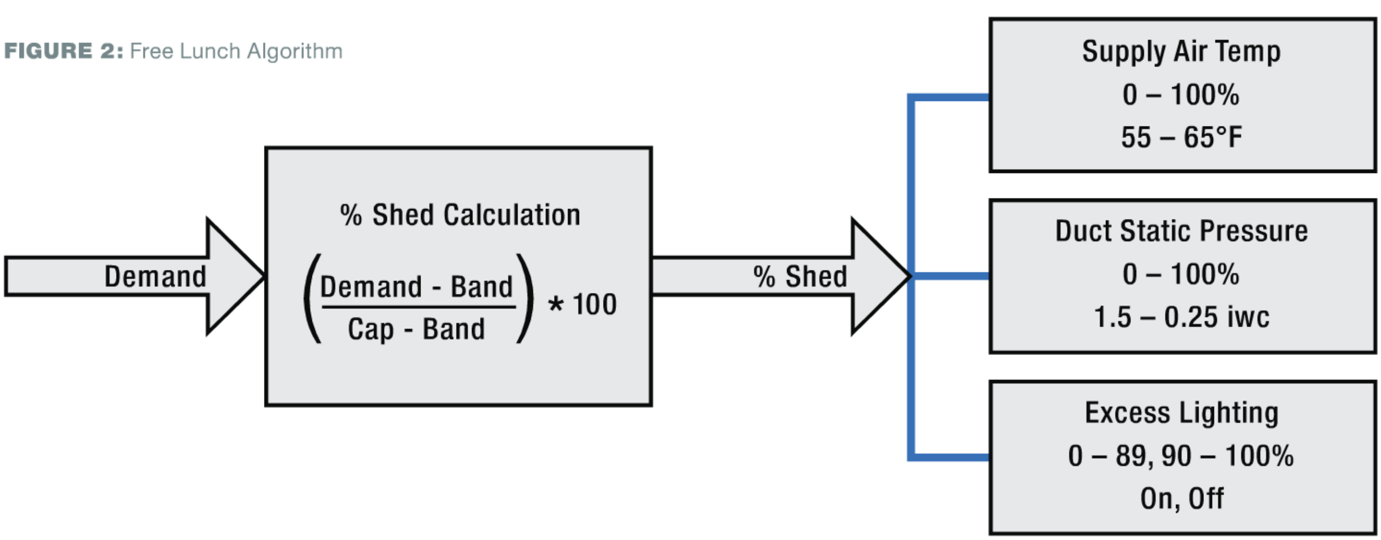
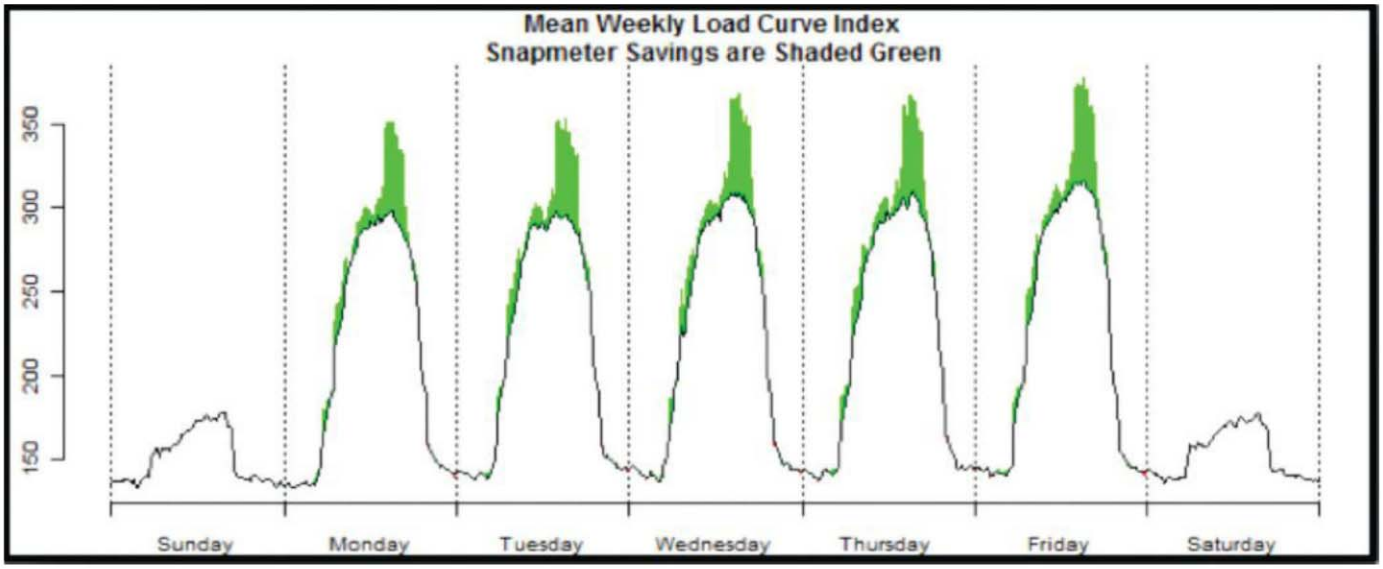


FIGURE 3: Median Load curves, before and after demand management. The green portion indicates demand savings.



trolled to significantly reduce demand charges. Echelon uses an inexpensive ($50 a month) commercial service called Snapmeter from Gridium. The Snapmeter notification informs the staff which days are most likely to set new demand peaks during the billing cycle. The staff will implement conservation efforts when they see the demand approaching the predicted peak.

After some initial verification of return on investment (ROI), the staff developed their algorithm, which would automatically hold the demand below a certain cap kW. It was called the free lunch algorithm because it started generating savings almost instantly and had a very short payback period. The cap kW is set at demand levels expected for a given billing cycle's normal weather. The algorithm manipulates the same building systems used in a demand response event, but with a finer level of control. Three simple techniques are used: raising supply air temperature to reduce the load on the compressors; lowering duct static pressure to reduce the load on the supply fans; and turning off non-essential lights. The controls allow nearly instant feedback.

The algorithm takes cap and band kW numbers (see Figure 2) and calculates the difference. The difference, or band, is calibrated from 0 to 100. As the demand climbs during the specific day that a cap has been set, a "percent shed" number is generated. The percent shed is used to adjust supply air temperature between 55 and 65 degrees, and duct static pressure between 1.5 and 0.2 inches of water. Additionally, at 90 percent shed the non-essential lights turn off.

For example, if cap is 300 kW and band is 250 kW, when the demand reaches 275 kW the algorithm will set percent shed at 50, supply air temperature will be set at 60 degrees and duct static pressure will go to 0.85 inches. To further our example, once the demand reaches 295 kW, a little while later the non-essential lights will be turned off.

Figure 3 shows the total savings from implementing the free lunch algorithm, comparing a normalized model of energy usage before and after demand management was started. Total program savings have been $6,806 over six months. The most recent bill has savings of $558 in usage (4.4 percent of line) and $922 in demand (15.3 percent of line). This was a reduction of $1,480, or 8.2 percent of the bill. Demand management is most effective in the spring and fall because of the wider temperature variations during the billing cycle, but building staff expects stable savings through the summer and winter.

Conclusions and recommendations

Demand charges are an increasing portion of utility bills. Facilities professionals should understand their local demand charges as a portion of the total bill, and examine whether a demand management program fits with energy program objectives.

Most organizations can start a demand management program simply, using off-the-shelf forecast software and manual intervention to avoid the most damaging peak demand charges. real estate assets equipped with modern controls systems can be programmed to use the free lunch algorithm. Organizations should expect automatic and significant year-round reductions in electricity costs.

For buildings without modern controls, a simple control system devoted to this algorithm will cost between $5,000 and $8,000, and using the case study, should provide a savings of about $12,000 a year and should pay back in less than a year for a facility of 75,000 square feet. We recommend that all managers responsible for the utility budget line item implement manual demand management. Additionally, feasibility estimates to program existing control systems that implement an automatic demand management, should be examined for an attractive ROI and use of the free lunch algorithm. FEJ

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