On Demand Savings: Introducing Demand Management in an Efficiency World

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ABSTRACT

The power (kW) component of customers' electricity bills continues to rise due to market and regulatory changes while energy (kWh) costs remain relatively stable. Shifting customers' attention from managing energy to managing power requires education, tools and motivation. This paper will present the program design elements and initial customer returns of an innovative pilot intended to motivate commercial and industrial (C&I) customers to better understand and manage the costs associated with peak summertime demand (kW) charges.

The On Demand Savings (ODS) Program is an 18-month pilot program funded by Focus on Energy, Wisconsin utilities' statewide program for energy efficiency and renewable energy. The ODS Program provides targeted C&I customers with a real-time energy dashboard, demand limiting strategies, and financial incentives to help control summertime on-peak demand. The intent of the Program is to determine if customers will place greater emphasis on managing their electrical load profile during critical on-peak periods through operational and behavioral modifications via their existing energy management systems and the customized energy dashboard.

Preliminary findings from a very small sample set show customers reduced their on-peak demand by an average of 21%. These preliminary savings were achieved primarily through programming changes to the energy management system that shifted HVAC cooling away from the peak demand periods. Survey results found that customers have a better understanding of their electric demand and strategies to reduce peak demand as a result of participating in the ODS Program.

Introduction

Energy efficiency programs administered by public electric utilities and government agencies have often been designed to help customers save money by reducing their energy consumption. This design encompasses all rate classifications, from residential to large commercial and industrial businesses, as they are all billed on the amount of kilowatt-hours (kWh) consumed. The implementation of energy efficiency programs has led to persistent ratepayer and utility benefits, not only in energy savings but in reduced carbon emissions and job creation (ACEEE).

Energy efficiency programs are part of the reason energy sales have been relatively steady over the past 7-10 years (Morash, 2016). In that same time, however, Figure 1 shows that generation for summer capacity has risen, which is an indicator of growing peak demand (Morash, 2016).

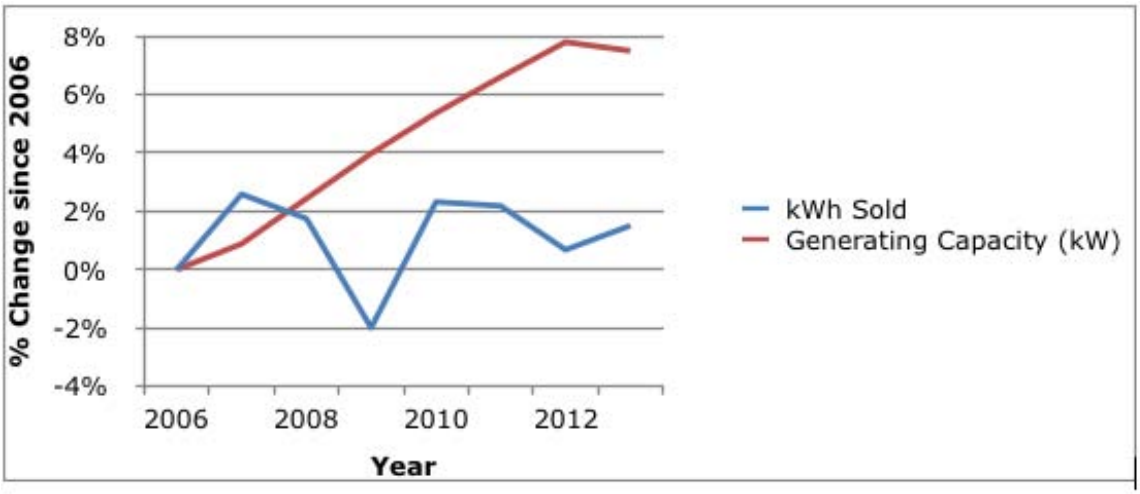

Figure 1. U.S. electricity retail sales vs. summer generating capacity, 2006-2013. *Source:* EIA Electric Power Annual Report, 2016

While much focus has been given to helping customers reduce their energy consumption, less attention has been given to helping customers save power (kW), which typically makes up 30-70% of commercial customers' electric bills (USDA, 2016). Energy efficiency programs could benefit from educating consumers when to conserve energy to reduce the customer's bill and limit further generation capacity investments.

Demand charges have the potential to increase as evidenced by rate cases recently approved in Wisconsin. In the past two years, three rate cases increased demand charges by an average of 9% (PSCW, 2014). Figure 2 shows the average demand increases for small business and C&I customers for each of the three electric utilities. In addition, Figure 2 shows an average decrease in energy charges (both on-peak and off-peak) of 1.6%.

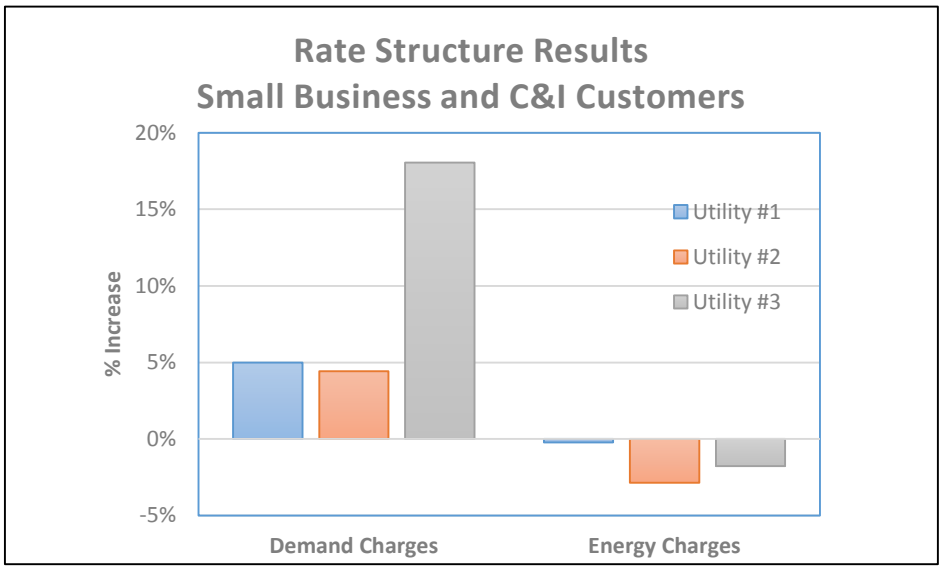

Figure 2. Percentage increases or decreases on utility bill charges as a result of approved Wisconsin rate cases, 2014 vs. 2015. Sources: Docket 3270-UR-120, Docket 5-UR-107, Docket 6690-UR-123.

In response to these emerging rate cases, the National Governors Association convened a summit in the summer of 2014 with Focus on Energy Program stakeholders to supplement the existing Program offerings. The goal of these offerings was to further motivate customers to better manage their utility costs in the wake of impending utility rate changes that would drive up fixed charges, demand charges, standby charges, and slightly reduce energy charges. The end result was a $2 million grant provided by Focus on Energy to design and implement a pilot program in partnership with Madison Gas and Electric (MGE) to provide targeted electric demand customers with education, tools, and financial incentives. The pilot objective was to help customers better understand their summertime on-peak demand charges and better understand strategies to reduce that demand by leveraging their existing energy management system (EMS). This Program would be referred to as the On Demand Savings (ODS) Program.

Program Design Elements

The ODS Program is not a demand response program or utility curtailment program in which a utility broadcasts price signals to their customers to shed load due to electric grid constraints. These demand response (DR) programs primarily benefit the utility because customers are shedding load based on the utilities' needs. Customers receive a financial incentive for participating in the program, but this participation may not reduce the utility demand charges on the customer's monthly bill for the facility.

The objective of the ODS Program is to create a program that is complimentary to traditional efficiency programs that focuses on customer initiated load shedding activities during peak events within their facility. The Program focuses on a customer's unique demand profile and educates that customer on when it is most advantageous for them to shed load to maximize cost savings on their utility bill based on their current rate structure arrangement with the utility. In this way the ODS Program is unique from traditional DR programs in that the customer is the primary beneficiary of the DR event because of the significant cost reduction on their utility bills.

Program Overview

The On Demand Savings (ODS) Program is a customer engagement program that educates customers on their electric demand charges and building demand profile and assists customers in identifying and implementing strategies to reduce their monthly on-peak demand. The Program educates customers on their utility demand charges, highlighting hours in which power is more expensive, and compares it to the hours of high demand for the facility. The Program helps the customer identify and implement behavioral load shedding strategies, both automated strategies that utilize an energy management system (EMS) and manual load shedding strategies implemented by facility staff during the periods of peak demand for the building. Customers had to meet the two criteria to be eligible for the ODS Program:

- Electric demand customer of MGE – business customers with a demand greater than 20 kW
- Onsite EMS that controls critical building loads with the ability to initiate load shedding strategies through automated intervention of building equipment when operable

Baseline Creation Methodology

The customer's monthly baseline is established from actual 15-minute interval data received from MGE for the on-peak periods from the previous two years. The on-peak period is Monday through Friday, 10AM-9PM, excluding holidays. A baseline is created for each month of the incentivized summertime period of June through September.

A temperature load analysis is performed for each facility to calculate a temperature correlation to outdoor dry bulb temperature. If a strong correlation exists, the Monte Carlo Statistical simulation is used. If a strong statistical correlation does not exist, a baseline is created for each summer month that would include the maximum values of every 15-minute interval between 10 AM – 9 PM. The majority of customers have this type of baseline which is shown in Figure 3.

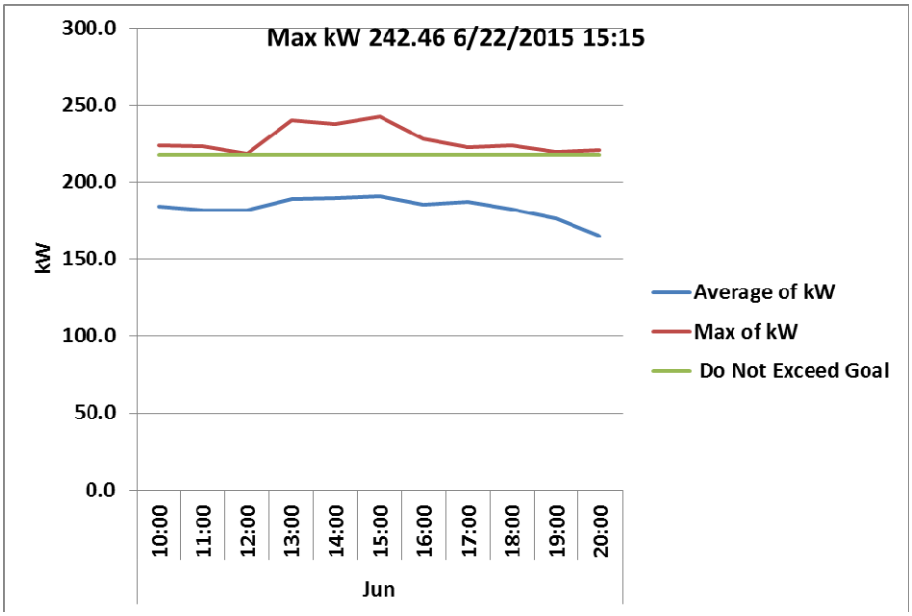

Figure 3. Example of a customer's June baseline graph.

Figure 3 above provides three distinct plots:

- The average of kW plot shows the average customer kW values for each hourly interval for the previous two years for that particular month.
- The max of kW plot shows the customer maximum demand values for the two previous years for that particular month.
- The horizontal "Do Not Exceed Goal" line provides a visual representation of the customer's demand reduction goal, which is typically set at 10%.

ODS Program Incentive Structure

As part of the ODS Program, the customer's primary responsibility is to identify demand limiting strategies that can be implemented without negatively impacting the day-to-day operations inside the building. The customer is given a goal of a 10% demand reduction compared to their baseline and is eligible to receive financial incentives based on the actual monthly demand reduction.

Customer Financial Benefits. The customer is eligible to receive a monthly incentive of $10 for each 1 kW reduction for each summertime month. For example, a customer may save 55 kW in June, 50 kW in July, 60 kW in August, and 70 kW in September. The sum of the kW reductions is 235 which provides a customer incentive of $2,350 as shown in Table 1 (row 1). In addition to the Program incentive, customers will see savings on their monthly utility bill for reduced on-peak demand charges (row 2). If the customer sets their max demand during the on-peak hours, which is common for office buildings, they will see reduced monthly max demand charges (row 3). Depending on the strategies implemented, the customer may see reduced consumption charges (row 4).

Table 1. Example of customer incentives and utility bill savings

Utility/Program Cost Savings Category	$/kW	Cost Savings
ODS Incentives	$10/kW/month	$2,350
On-peak Demand Savings (set monthly)	~$0.45/kW/day	$3,230
Customer Max Demand Savings	~$0.10/kW/day	$1,930
Electricity Consumption Savings	~$0.10/kWh (base + peak)	$930
Total Savings:		$8,440

Customer savings calculations assume the customer max demand is set during the summer months and the actual on-peak demand savings are a 10% reduction compared to baseline.

Trade Ally Incentives. The customer is encouraged to work with an in-house EMS programmer or an EMS contractor, also referred to as a Trade Ally, to identify and implement EMS load shedding strategies. If the customer chooses to work with a Trade Ally, that Trade Ally is eligible to receive financial incentives based on the average monthly demand reduction. The Trade Ally is eligible to receive a summertime incentive of $100 for the average peak demand reduction for the four summertime months of June through September. For the customer example given above, the average monthly demand reduction is 58.75kW, so the Trade Ally incentive would be $5,875.

Demand Limiting Strategies

The focus of the ODS program is to identify load shedding or load shifting strategies that customers can implement in a building for little or no cost. The primary focus of the Program is to identify strategies that can be programmed into an existing energy management system, as these systems often have the ability to control the equipment with the largest electric loads. In absence of an EMS or in addition to EMS programming strategies, the secondary focus of the Program is to identify manual load shedding strategies that can be implemented by building operators. These strategies can be implemented for no cost, but require the building operators to be available to implement strategies on-site during periods of high demand.

The Program holds a meeting with the customer, Trade Ally, and utility account manager to review the building demand profile and identify demand limiting strategies. The strategies selected depend on the business processes, building design, and EMS system capabilities.

EMS Programming Strategies – HVAC. The most variable electric load for a building in the summertime is usually the heating, ventilation, and air conditioning (HVAC) system, which is often controlled by the EMS. The EMS programmer or Trade Ally can incorporate the following demand limiting strategies into the EMS programming.

- Precool spaces or chilled water before the start of on-peak hours.
- Raise space or chilled water setpoints during high demand hours.
- Rotate cooling zones and cycle compressors to reduce the instantaneous load.
- Optimize chiller plant efficiency by adjusting the individual chiller loading and lead/lag operation.
- Disable on-peak defrosting.
- Create a building schedule based on expected occupancy or occupancy sensors to reduce cooling and ventilation to unoccupied spaces.
- Review room type ventilation requirements and reduce airflow to lowest acceptable levels.
- Program demand (kW) thresholds into the EMS.
- If available, utilize thermal energy storage during high demand hours.
- Utilize absorption chillers during high demand periods.

Not all buildings have an energy management system and many of the above EMS programming strategies can be performed manually. The customer may enlist the help of an alternative Trade Ally such as a refrigeration contractor or building management company to implement these strategies manually.

EMS Programming Strategies – Lighting. Lighting fixtures connected to the EMS can be controlled to reduce the building electric load during peak periods. Demand limiting strategies for lighting include creating schedules based on expected occupancy or occupancy sensors, utilizing daylighting sensors, and decreasing redundant lighting through dimmers or bi-level lighting.

Manual Strategies. Not all equipment is tied to a building EMS. For this equipment that isn't tied to the EMS, the customer is encouraged to turn it off, delay use, or reduce the energy consumption.

- Turn off unnecessary equipment, non-essential lighting, unused kitchen equipment, idling exhaust hoods, decorative water fountains, and redundant elevators.
- Delay dishwashers, washers, dryers, sterilizers, trash compactors, and forklift chargers.
- Reschedule processes for off peak hours such as work on manufacturing equipment, large R&D tests, and equipment testing.
- Reduce pool pump cycles, reduce refrigerators or freezers set points, and use energy-saving mode for major diagnostic equipment.

Overview of the Customer Energy Dashboard

The ODS Program provides a customer energy dashboard at no cost to ODS customers to help them track and manage their on-peak demand as well as their energy consumption over time. The dashboard allows customers to see their historical and real-time demand in monthly, daily, hourly, or 15-minute intervals. Two years of the customer's historical data is loaded into the portal for analysis. A piece of hardware is connected to the electric meter at the customer site to send real-time data. As shown in Figure 4, the dashboard allows the customer to overlay a trend line for the average temperature. Additional trend lines can be added to show the usage on the same day the previous year or from the same day two years ago.

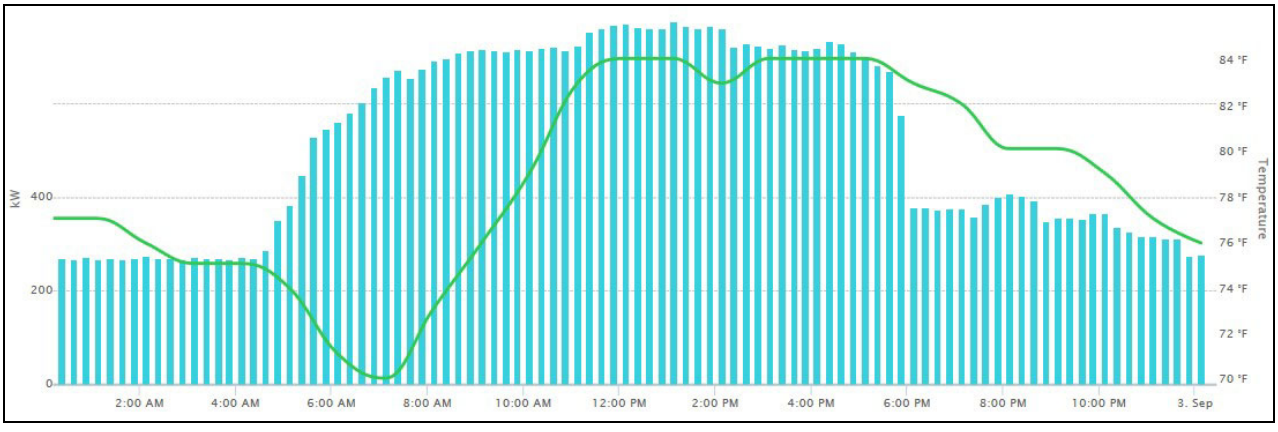

Figure 4. MyMeter energy dashboard 15-minute interval demand chart.

The customer data can also be viewed as a heat map, which is a data table that uses a color gradient to represent the values. The highest demand intervals are colored bright red and the lowest demand intervals are colored bright blue. This table allows customers to quickly

identify periods of high demand for their buildings (Figure 5). If customers have a schedule or record of events, they may be able to identify the source of the demand and adjust their processes to avoid a future spike.

Hour by Day	12-1am	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-1pm	1-2
9/20/2015	264.0	--	--	--	--	--	--	--	--	--	--	--	--	--
9/19/2015	257.4	262.8	258.6	259.2	266.4	261.6	262.8	273.6	285.6	280.2	283.2	285.0	283.8	281.4
9/18/2015	256.8	260.4	258.6	258.0	262.8	535.2	602.4	647.4	643.8	634.2	651.6	683.4	676.2	674.4
9/17/2015	270.0	266.4	272.4	277.8	280.2	523.8	587.4	607.8	671.4	675.6	690.6	700.8	705.0	696.0
9/16/2015	267.0	264.6	265.8	288.0	291.6	503.4	585.6	596.4	659.4	688.2	708.0	705.0	713.4	717.0
9/15/2015	272.4	273.0	270.6	267.6	276.0	533.4	597.0	610.2	681.0	684.6	697.8	706.8	724.8	718.8

Figure 5. MyMeter energy dashboard hourly interval heat map.

At the top of the portal, several customized Program widgets give the customer a snapshot of their demand as shown in Figure 6. The Latest Read widget shows the most recent demand read (570kW) and compares it to the customer's demand reduction goal (647kW). The customer can quickly see that their current demand is at 88% of their reduction goal. The Goal widget shows the customer's reduction goal and how they are tracking against the goal for the current calendar month. The Peak Demand Events widget gives the customer a snapshot of their max demand in the recent day, week, month, and three month periods. The Load Reduction Strategies widget links customers to a previously selected list of demand limiting strategies.

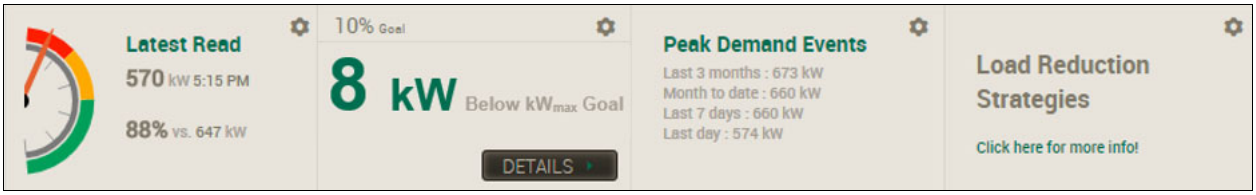

Figure 6. MyMeter energy dashboard customized widgets: Latest Read, Goal, Peak Demand Events, Load Reduction Strategies.

Customers can view their demand reduction goal in the chart view as well (Figure 7). Users can easily see when they are nearing their reduction goal. The shaded areas indicate which demand values are occurring during the utility's on-peak billing window.

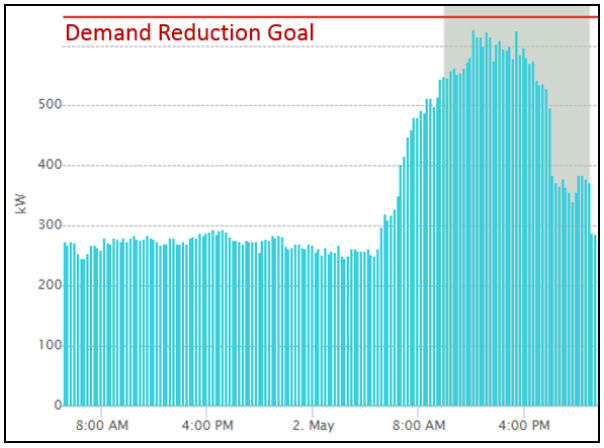

Figure 7. Energy reduction goal in chart view.

The energy dashboard also allows the user to create threshold notifications. The software is capable of sending messaging to facilities staff via email or text to notify them when the thresholds have been exceeded. The recipients can log in to the dashboard to reference their preselected list of manual strategies and take immediate action.

The dashboard also allows the customer to create energy markers that show up in the chart and data table. The customer can add markers to record events, energy efficiency upgrades, or manual demand limiting strategies.

Customer Success Stories

After meeting with the Program team, the customer works with their Trade Ally to program the demand limiting strategies into the EMS, however, some of the tools described above were not available to the customers during this period. The following are examples of customers' stories of the ODS Program. For the three customers who implemented strategies in September 2015, the only month that was incentivized, demand and incentive data has been collected and calculated.

Cold Storage Facility

A cold storage facility reduced their on-peak demand by 345kW (37%) compared to their September baseline. To achieve these savings, the customer programmed two automated strategies into the EMS.

First, an on-peak demand limit was set in the EMS. The utility's electric pulse meter was connected to the EMS to create a real-time demand reading in the EMS, and a 450kW on-peak demand limit was created in the EMS as shown in Figure 8. When the real-time demand reading exceeded 450kW during on-peak hours, additional programming forced the evaporators to shut down to save power. Second, the evaporator coil defrost cycles were limited to off-peak hours, however, the system would override this setting if needed to maintain product temperature.

Figure 8. Cold storage facility EMS programming

College Science Center

A college science center reduced their on-peak demand by 59 kW (17%) compared to their September baseline. To achieve these savings, the EMS programmer added a cooling schedule to the EMS.

The Trade Ally programed a precooling schedule into the EMS for 1AM to 9:30AM daily to cool the building before the start of the on-peak period at 10AM. He also increased the variable-air-volume (VAV) box temperature deadband by several degrees to allow the building temperature to float 5°F above the temperature setpoint before calling for cooling.

Department Store

A department store reduced their on-peak demand by 24 kW (12%) compared to their September baseline. To achieve these savings, the EMS programmer adjusted the space cooling settings based on multiple factors.

The Trade Ally programed a precooling schedule into the EMS for days forecasted to be 85°F to 100°F. The higher the forecasted temperature, the earlier the cooling was programmed to start. The Trade Ally also programmed a demand threshold into the EMS which disabled individual stages of cooling on roof top units throughout the store, however, the programming did not disable more than 50% of the cooling stages on any one unit. Starting two hours before store close, the cooling setpoint was programed to increase by one degree every 20 minutes until it reached the unoccupied cooling setpoint.

R&D Testing Facility

An R&D testing facility joined the ODS Program after the 2015 incentive period. The facility had a single digit load factor and wanted to reduce their demand without delaying product shipments. The customer did not have an EMS, but could measure the demand at all five test bays with a test management software. After meeting with the ODS Program team, the customer rearranged the testing schedule to reduce the on-peak demand. As shown in Figure 9, the customer scheduled high power loaded tests before peak hours and created a delayed start timer for the medium power burn-in tests to take place after the on-peak hours (10AM-9PM). The on-peak hours were utilized for testing preparation and validation. Lab equipment such as the wave machine was used prior to the peak hours and set to standby mode during the peak hours.

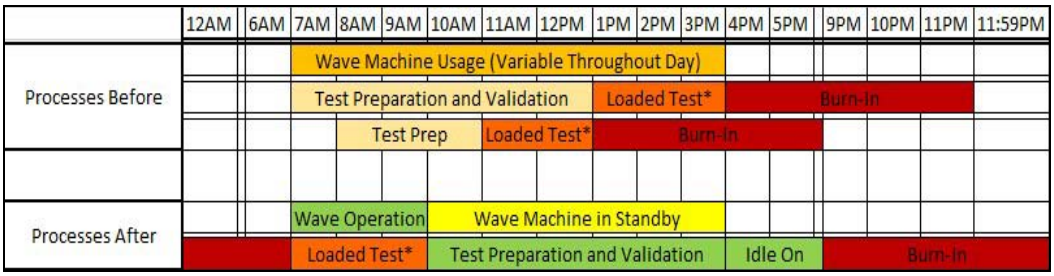

Figure 9. R&D testing facility process before and after meeting with the ODS Program.

Summary of Program Savings and Incentives

The savings for the three customers that implemented strategies in September 2015 are summarized in Table 2.

Table 2. Summary of demand reductions and incentive payments.

	Average	Total
Customer Savings (kW)	143 kW	429 kW
Customer Savings (%)	21%	N/A
Customer Incentive	$1430	$4290
TA Incentive	$4171	$8342

The average customer reduced their demand by 21% compared to their baseline and had an average incentive of $1,430 for the month. Customers were given a goal of a 10% reduction, and while the 21% reduction is promising, the sample set is very small.

Customer Experience Survey Results

A third party evaluator conducted a survey to gauge the customer experience during the early stages of the Program. Nineteen of the total 42 customers were enrolled at the time, and 11 of the 19 customers were available for a phone interview resulting in a 58% response rate. A key section of the survey focused on the customer's understanding of demand and demand limiting strategies as a result of the program.

The survey found that the majority of respondents have a better understanding of their demand and a better understanding of demand reduction strategies to reduce peak demand, as a result of participating in the ODS Program. The survey found that over half of the participants said the ODS Program had changed their thinking about using their energy management system. Overall, the survey found that participants are highly satisfied with their program experience.

Naturally Occurring Utility Benefits

MGE has three on-peak billing windows for June through September: 10AM-1PM, 1PM-6PM, and 6PM-9PM. MGE's highest grid capacity occurs during the second timeframe in which on-peak energy rates are the most expensive. Like many utilities, MGE may need to purchase more expensive power during high use periods. Although the ODS Program does not include a direct load control component in which MGE broadcasts a message or shuts off equipment, MGE will benefit from participants in the Program managing their facility-specific on-peak demand spikes. Figure 10 illustrates the time of the ODS customers' peak demand for the summer months for the past two years.

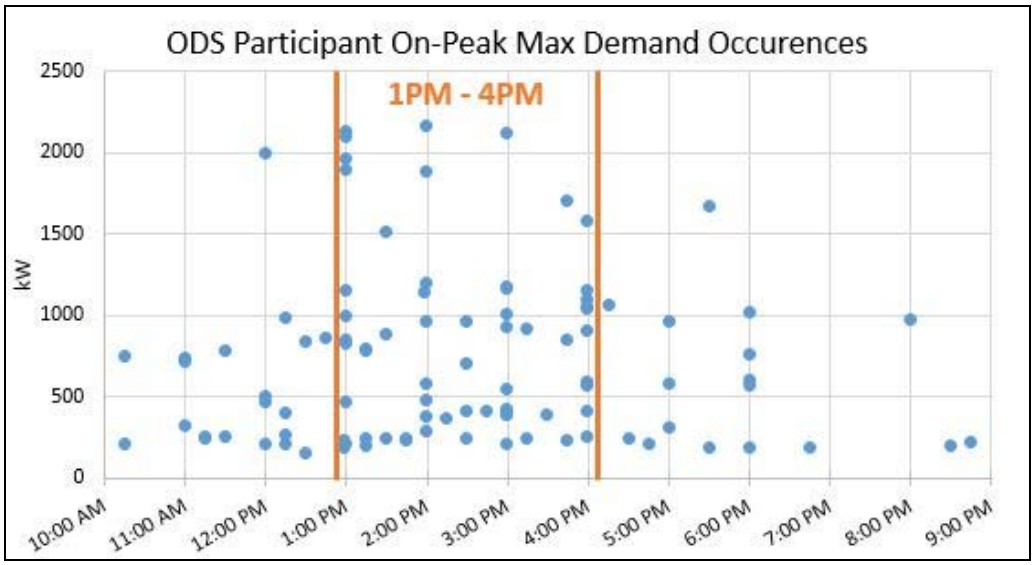

Figure 10: ODS participant on-peak max demand occurrences.

As Figure 10 illustrates, most max demand occurrences fall within the 1PM-4PM window in which the highest grid capacity occurs for MGE. By reducing large customer on-peak demand, MGE would experience less demand on their grid during peaking times. One could draw the conclusion that implementing a program centered around customer demand education and reduction would naturally reduce the utility's demand for power at critical times.

Conclusion

The prevalence of energy efficiency programs has leveled off energy consumption over the past decade. Given the recent utility regulatory trends that devalue the energy charges on utility bills and place greater emphasis on customer demand charges, it makes sense to introduce programs centered around on-peak demand management through customer education and performance-based financial incentives. The ODS Program has empowered ratepayers to understand how and when they consume the most energy and how it impacts them financially given the utility rate structure. The early returns of the Program are very positive, with customers that participated in the summertime 2015 period experiencing monthly on-peak demand levels on average 21% less than their baselines. They also expressed a greater understanding of how their on-peak demand charges impacted their utility costs and that they are better equipped to take action within their existing operations to limit their on peak demand. If utilities and energy efficiency programs want to supplement traditional efficiency programs with a program offering that allows their ratepayers to mitigate their demand charges, they should strongly consider a behavior-based Program similar to ODS.

References

American Council for an Energy Efficient Economy. 2016. http://aceee.org/portal/programs

Morash, S. 2016. "How the Relationship between the kW and kWh is Changing Utility Operation." Environmental Leader, Environmental & Energy Management News, February 25, 2016, http://www.environmentalleader.com/2016/02/25/how-the-relationship-between-the-kw-and-kwh-is-changing-utility-operation

United States Department of Agriculture, 2016. http://www.fs.fed.us/t-d/pubs/htmlpubs/htm00712373/

Public Service Commission of Wisconsin 2014. Case 3270-UR-120. December 23, 2014 https://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=226563

Public Service Commission of Wisconsin 2015. Case 5-UR-107. January 21, 2015. https://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=230196

Public Service Commission of Wisconsin 2014. Case 6690-UR-123. December 18, 2014. https://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=226374

Focus on Energy. 2016. https://focusonenergy.com/about.

Federal Energy Regulatory Commission. 2015. http://www.ferc.gov/industries/electric/indus-act/demand-response/dem-res-adv-metering.asp