PIVOTal Agricultural Demand Response

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AESP's 23rd National Conference, January 2013

Abstract

It is estimated that demand response (DR) at agricultural facilities represents more than 10,000 megawatts of highly cost effective DR potential in the United States, mostly from pivot and drip irrigation pump load. Despite this vast opportunity, the agricultural sector has proven hard to reach through traditional utility programs, so this resource has remained largely untapped. Remote locations, lack of cost-effective communications infrastructure, and customers with unique operational goals are just a few of the factors that make it difficult to implement programs. However, using Midwest Energy's Pump$mart Irrigation Load Control program as a case study, this paper will show how utilities throughout the U.S. can work with this challenging customer segment to unlock the agricultural DR potential in their territories.

This paper highlights a case study of Midwest Energy, Inc, an electric cooperative which serves 49,000 electric and 42,000 gas customers throughout a portion of western Kansas. Facing significant load growth, expiring purchased power contracts, limited options for new sources of capacity, and transmission constraints which further limit bilateral purchase options, Midwest Energy decided to explore alternative solutions to satisfy their capacity needs.

Understanding that irrigation pumping load represents approximately 55 MW of demand that has a high coincidence with system peak, Midwest Energy postulated that by leveraging the right technology and the right program structure, they could develop a cost-effective substitute for peaking generation. In 2010 Midwest partnered with M2M Communications (now part of EnerNOC) to conduct a pilot agricultural DR program that focused on relatively short interruptions of irrigation pumps during peak hours of the summer months while avoiding adverse impacts on crops.

A 2010 pilot program achieved its goals: it ramped up on schedule, delivered a firm resource, and increased customer satisfaction. In 2011 Midwest Energy more than tripled the size of the program, exceeding both subscription and performance targets. This case study will delve into how Midwest Energy created a successful resource, including:

1. Economic drivers that impacted Midwest Energy's resource decision and pricing, including avoided cost considerations.
2. Program design that was created to eliminate customer concerns and drive participation while providing Midwest Energy dispatch flexibility to receive the maximum capacity benefit.
3. Sales and marketing strategies that are tailored to reaching agricultural customers, including holding town hall meetings that build community support to educate farmers.
4. Incentive levels to drive customer participation and increase satisfaction.

5. Flexible technology platform that provides two-way communication devices, multiple channels of automated communication to participants and online tools that enable growers to control their pumps outside of control events.
6. Cost effective EM&V data gathering, including the ability to satisfy stringent NERC/SPP capacity and reserve calculation requirements while allowing Midwest Energy to take advantage of low-cost grid energy when available.

This paper provides insight into how an agricultural DR program can cost effectively fit into a utility's resource plan.

Introduction

Midwest Energy, Inc serves 49,000 electric and 42,000 gas customers in a 41-county area that includes most of the western half of Kansas. Its mission is to provide safe, reliable, and efficient energy services to these customers—and to deliver innovative, affordable, and environmentally sound solutions. As a vertically-integrated and customer-owned energy company, Midwest Energy provides both electricity and gas to its customers through a combination of owned and contracted generation capacity.

Incorporated in 1939 to provide affordable, reliable electric power to a rural area, Midwest Energy continues to take pride in the strong agricultural community that it serves. Run as a non-profit, the company is governed by a nine-person Board of Directors comprised mostly of farmers who are intimately aware of the needs and challenges of the agricultural customer base.

Midwest Energy has experienced significant load growth, with retail electric sales increasing 23% from 2006 to 2011, reaching 1.6 million megawatt hours in 2011. Natural gas deliveries increased 17% over the same period. As is the case in many rural service territories around the country, the Midwest Energy system has a summer peaking load of 354 megawatts of retail load with a peak driven largely by about 100 MW of residential and 55 MW of irrigation load – both of which are highly coincident with the system peak.

This growth led the Midwest Energy to search for cost-effective strategies to meet rising demand. The Company also faces significant capacity cost increases, due to the higher cost of new purchased or owned generation.

This paper will discuss how, through its innovative demand response programs, Midwest Energy was able to cut its generation capacity requirements (including reserves) by 5.7% based on the new peak set in the summer of 2012.

Economic Drivers

There were several reasons for Midwest Energy to seek demand response solutions.

The most obvious driver has been the growing load in the service territory – growth which is expected to continue at a rate of 1.5 – 2% for the next 20 years. This staggering growth in electric demand can be attributed to a variety of factors, all of which stem from the notable, positive economic growth in the region in recent years. While the rest of the country was coping with the so-called Great Recession, western Kansas businesses have prospered. Farmers have required more power for irrigation load as there has been an active shift toward the electrification of the diesel motors that powered the irrigation pumps. Compressor stations associated with new pipelines moving oil, gas, and petroleum products across the state have added huge new loads. Ethanol production continues to increase. Energy demands associated with horizontal drilling technology are just starting in western Kansas, with potential production from Mississippi shale similar to that occurring in the Bakken Shale formation in North Dakota.

Increased demand was not the only challenge facing Midwest Energy. Simultaneously, several purchased power contracts were nearing expiration. Further, the system's infrastructure was aging and a recent series of ice storms – five FEMA projects in four years - added to the need for significant reliability upgrades. Finally, transmission constraints existed (and continue to exist) within the Southwest Power Pool (SPP) footprint. There was limited access to outside sources of supply. These constraints were exacerbated by the multitude of wind farms requesting connection to the Midwest Energy transmission system. Requests for connection by wind farms were roughly triple the size of Midwest Energy's native load. The Company has had no choice but to invest in transmission infrastructure, leaving capital tightly constrained. On top of all this, Midwest Energy faced a challenging regulatory environment should it seek to build new sources of capacity. In recent years, the ability to build much-needed base load capacity has proven to be just about impossible in western Kansas. The widely reported Holcomb power plant expansion has been successfully stalled largely by well-funded, out-of-state environmental groups.

Midwest Energy evaluated various options to address the system limitation and challenges, and specifically the need to reduce the system peak. In addition to irrigation load control, the company considered residential, small commercial and industrial (C&I), and large C&I programs as possible alternatives. However, irrigation load control (and some very selective interruptible rates for large C&I customers) stood out as the most cost effective options that could have an immediate impact. It made sense to start with the irrigation class first.

History with DR & DSM

While Midwest Energy's history with demand response and demand side management of agricultural customers was somewhat limited, the cooperative has operated a successful residential and business-focused energy efficiency program for several years.

The How$mart® portfolio of programs allows customers to pay for energy-savings projects with no upfront costs through shared savings via monthly bill savings, or on-bill financing.

Participating home or business customers start with an energy audit to determine savings potential. Midwest Energy then uses the data and findings from the audit to develop a conservation plan with suggested improvements. Eligible measures include upgrades to insulation, sealing, HVAC, and lighting.

Through October 2012, over 800 projects were completed, with $4.7 million investment on the part of Midwest Energy, added to another $1.4 million contributed by customers to cover costs not offset by energy savings. Annual savings are estimated at 1.8 million kWh and 220,000 therms. While Midwest Energy was very pleased with the energy savings achieved, the innovative approach employed by Midwest Energy has also been recognized nationally. To date, the How$mart® program has won numerous awards including AESP's Best Residential Efficiency Program for the year of 2011, and, even more recently, the National Rural Electric Cooperative Association selected Midwest Energy from its 841 distribution cooperative members to receive the National Community Service Award in Energy Efficiency.

Building on a legacy of success in energy efficiency program implementation, Midwest Energy felt that this success could be replicated in a properly structured demand response program and that irrigation pumping load, which tends to be have a high coincidence with system peak, was the logical choice given the low cost to implement. A past attempt by Midwest Energy to address peak load leveraged a Time of Use (TOU) rate design which included extremely high on-peak rates - more than triple the off peak rates. If there ever was an instance of trying to fit a square peg in a round hole, this was it for agricultural customers. To avoid the incredibly high peak pricing, they were interrupted for many peak hours, but on the hottest of hot summer days, farmers concerns for their crops would exceed their concern for managing costs and they would disregard the pricing signals and irrigate through the peak hours when the utility was in most need of that capacity reduction. It quickly became clear that a pricing scheme targeting energy was not the best way to save capacity with this customer class. Protecting the health of the crops in the field greatly trumped the farmers' desire to avoid many hours of peak electricity pricing.

Demand Response Pilot and Program Design

Midwest Energy serves approximately 2,000 agricultural accounts, which it estimates account for approximately 55 megawatts (MW) of peak irrigation load. During hot summer months, Midwest Energy experiences high demand from these agricultural accounts, which use energy-intensive irrigation pumps. In order to leverage the large agricultural customer base to address the dual pressures of increased demand and limited cost-effective options to increase, Midwest Energy needed to design a demand response program that could interrupt more reliably, but less frequently, than the traditional TOU program.

After careful evaluation of technologies that could provide both real-time feedback and instantaneous control, Midwest Energy identified a technology-enabled demand response solution which would allow system dispatchers to manage load control events in real-time via

the internet. There was also an ancillary benefit in that participants were also able to control pump equipment directly from their computers and mobile phones outside of control events. In 2009, Midwest Energy partnered with M2M Communications (now part of EnerNOC) to conduct a pilot agricultural demand response program. During a demand response dispatch, irrigation wells providing water for pivot irrigation would be temporarily shut down without affecting crops and farmers would be compensated for their participation.

Through this program, Midwest Energy sought to remove the risk of participation from the farmer. They did this by setting - and sticking to - very clear program parameters which limited the number of calls to no more than 20 events per year, and limited the duration of interruptions to four hours per event. These limits were formed with the aid of farmers on the board of directors and through conversations with other member farmers. Most importantly, the farmers were given significant control over their participation in the program, meaning that they had the ability to opt-out of a given event should they feel that their crops would suffer by participating.

The full parameters for the Pump$mart Program are outlined in Table I below.

Table I – Pump$mart Program Details

Program Name	**Midwest Energy Pump$mart**
Program Trigger	Emergency or economic
Program Period	June, July & August
Program Hours	2 p.m. to 9 p.m. Monday through Saturday, excluding holidays
Event Notification	Minimum 2 hour notice via phone, fax and/or email
Event Duration	Up to 4 hours, 20 events max, 80 hours max/year
Strategy	Automated curtailment of irrigation pumping devices
Credit (kW-year)	$20 (1yr), $24 (2-3yr), $28 (4+)
Penalty	Irrigator can override but forfeits all credits for the year

Marketing

Midwest Energy targeted customers with peak summer demand greater than 30 kilowatts, which includes as many as 1,200 accounts. Participation in Midwest Energy's Pump$mart program is contingent on the use of at least a 40 horsepower motor at the pumping site. Sites with a 25 horsepower motor could participate by paying a $500 installation fee. For participation, Midwest Energy pays $20 per kW of interrupted capacity, with that rate escalating higher in subsequent years of participation.

The most compelling benefit for agricultural accounts to participate in the Pump$mart program was financial, since farmers always look for opportunities to cut costs and maximize revenues. Focusing exclusively on the financial benefits proved to be shortsighted as many of the farmers also embraced the other benefits associated with the program. Specifically the sense that they were also part of the solution to help manage overall energy costs for the Co-op proved to be a powerful motivator.

Reaching the customers in order to educate them about the benefits was the first hurdle. Agricultural customers are usually a geographically dispersed, hard-to-reach group. However, they also tend to be a very tight and close knit community. To get this message out in a clear and compelling manner, Midwest Energy and EnerNOC used a direct mail campaign to invite farmers to informal, yet informational town hall meetings. Midwest Energy offered midday and evening meetings in two central locations where potential participants in the program were located.

In the meetings, representatives from Midwest Energy took the time to explain *why* there was a need for demand response in the first place, which helped the customers in attendance understand the impact that their participation would have on the overall system. Simple registration forms - which requested information such as account number, legal description of the property, and contact information for any individual wishing to be informed at the time of a system interruption - helped to streamline the sign-up process and were in no way cumbersome to the farmers.

The meetings proved to be hugely successful. Not only did customers sign up for the program, but the meetings also provided an opportunity for dialogue between the farmers about the program. At these events, questions about the program centered on the potential operational impact and details about curtailment procedures, as well as the financial benefits. Many farmers had participated in a previous program that relied on hardware devices that were time and temperature-dependent. This earlier technology resulted in frequent and unannounced signals that on-peak rates were now in effect (a red light simply came on and some farmers utilized the signal to shut the pump down). Farmers were pleased to hear that the new Pump$mart program would be based on need, with potential shutdowns announced well in advance. There would be no on-peak rates for program participants. In short, the “no surprises” approach taken by Midwest Energy appealed to them. Further, the relatively few hours that customer load would be interrupted also appealed compared to the high number of hours at peak rates. Being interrupted for no more than 80 hours (and most likely much less) was more appealing than paying peak rates for more than 200 hours.

Beyond the town meetings, Midwest Energy account representatives placed individual calls and arranged individual meetings with farmers with multiple irrigation accounts – a personal touch that was appreciated by the farmers. Additionally, Midwest Energy created close to one hundred spreadsheets comparing bills under various rate scenarios to help the farmers understand and quantify the benefits to them. The advantages of the program were clear:

Pump$mart offered farmers the ability to run their pumps for more hours than the TOU rates and to do so without a penalty, and offered the added benefit of providing the technology to monitor and control the pumps remotely.

Results & Lessons Learned

Result Details

1. Program Size

The program has ramped up quickly: In the pilot year (2010) where Midwest Energy was testing the proof of concept, there were 45 irrigation pumps and over 1.8 MW of subscribed capacity. In year two, the 7 MW goal was exceeded with a total of 211 irrigation pumps and 10.5 MW subscribed load. As of the end of the 2012 irrigation season, there are now 361 irrigation pumps representing 17.2 MW of subscribed load.

Table II – Program Subscription Results

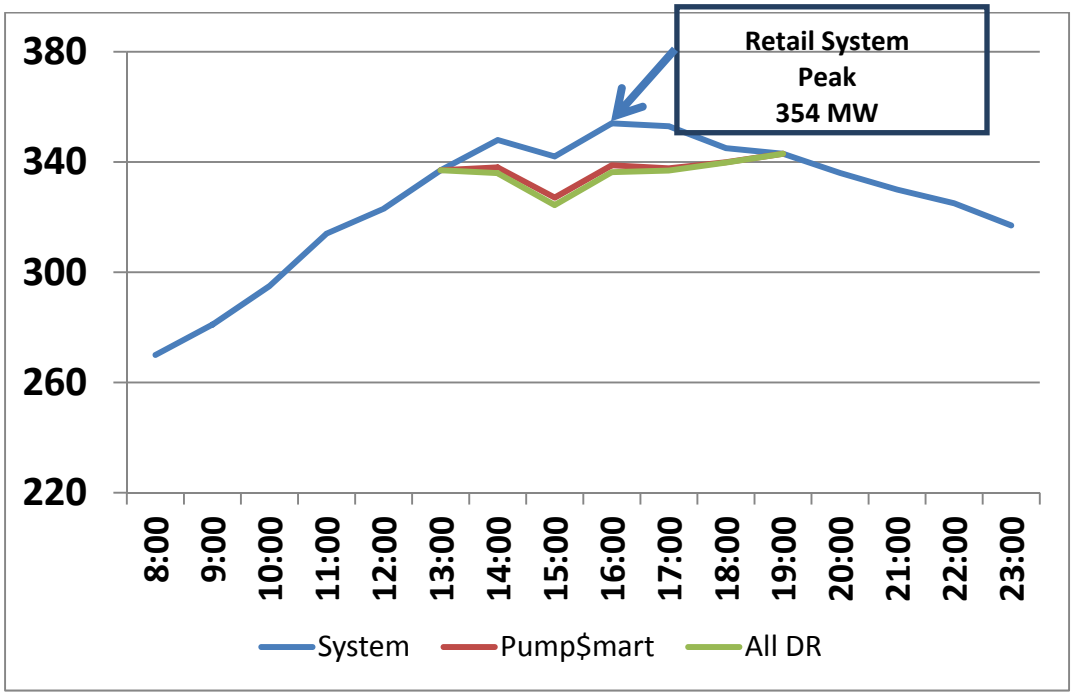
Year	Individual Customers Represented	Irrigation Pumps	Subscribed Load (kW)	Number of Dispatch Events
2010	**21**	**45**	**1,837**	**7**
2011	**56**	**166**	**8,622**	**4**
2012	**53**	**150**	**6,746**	**1**
Total	**130**	**361**	**17,205**	**12**

2. Interruptible Capacity

With the slow economy affecting areas outside of western Kansas, significant generation capacity has been available for spot purchases at attractive prices. That means that Midwest Energy has been able to avoid interruptions (only 12 in three years) to the benefit of the farmers. Further, because the demand response (DR) capability can be proven, Midwest Energy can reduce its system peak by the proven capability if - for economic reasons - it elects not to utilize the DR at the time of the system peak. In other words, peaking capacity and reserve requirements as established by regulatory bodies take into account DR capability and adjust system peaks accordingly. This is exactly what happened in 2012: generation and transmission access were consistently and economically available throughout the summer despite all-time record heat. At the time of its system peak, Midwest Energy did not call on DR resources

despite the fact that the Company's service area included the hottest place in the country on that day. (Hill City, Kansas reached 115 degrees on June 27th).

Chart I – System Load on June 27th, 2012



As illustrated by Chart I above, the DR capability at the time of the system peak and during the time of typical interruption events (phased in and out from 2 PM until 7 PM) could have significantly reduced the peak. During the peak hour, over 88.4% (15.2 MW) of the subscribed capacity in the Pump$mart program was available for dispatch.

3. Customer Satisfaction

Midwest Energy has followed-up with participating customers at the end of each program year. As of the time of writing, satisfaction results are just being gathered for the 2012 season. What is known is that for 2011, farmer satisfaction with Midwest Energy and the Pump$mart program is very high. Although there were 211 irrigation pumps enrolled in the program, those pumps were only tied to 77 customers (meaning close to 3 irrigation pumps per customer). A total of 73 surveys were mailed (all customers except 4 where the ground was changing hands). The response rate was phenomenal - 53% of the surveys were returned. Although the population (and thereby the sample) is small, some encouraging results were obtained. Satisfaction with Midwest Energy and the Pump$mart program were very high as seen in (Charts II and III).

Chart II – Satisfaction with Midwest Energy

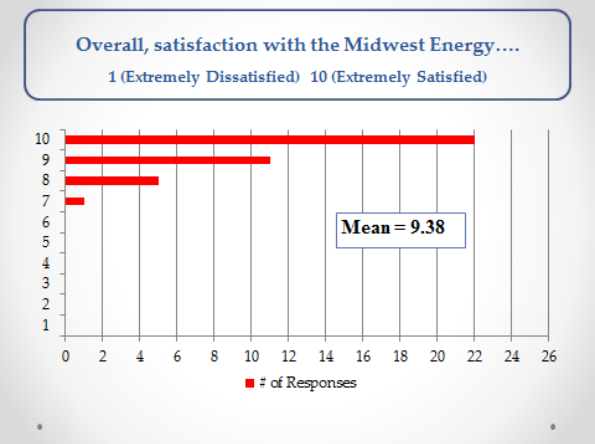
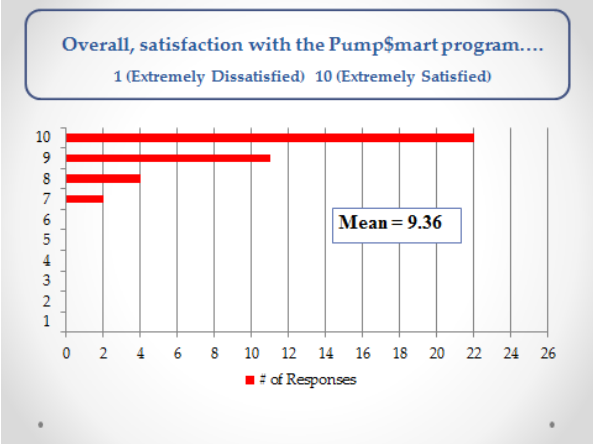


Chart III – Satisfaction with Pump$mart



The survey also yielded constructive information regarding the electrician subcontractors utilized to install the equipment and the equipment itself as seen in Charts IV and V below.

Chart IV – Satisfaction with Electrician

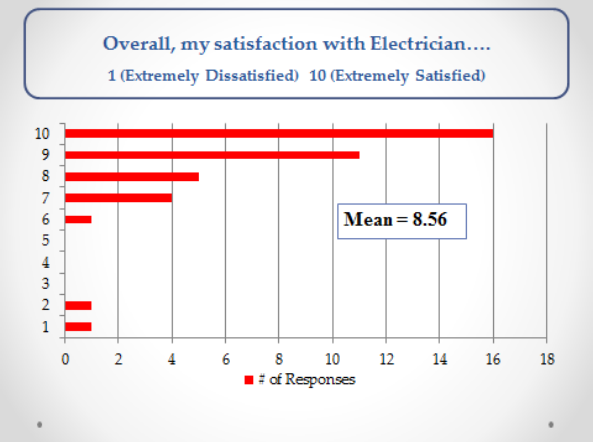
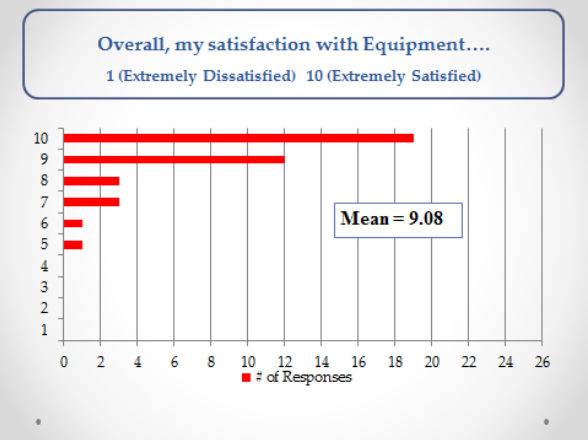


Chart V – Satisfaction with Equipment



While the satisfaction with the electricians (Chart IV) was lower than others – it still wasn't considered low by common standards. Follow-up discussion presented an opportunity: the biggest area of complaint with the electricians was inadequate communication regarding the time of the installation. Midwest and EnerNOC have encouraged farmers to be present when the electrician installs the equipment. Future installation timing will be managed more carefully such that farmers can be fully engaged in the installation process which will result in better farmer understanding of the equipment.

Finally, specific elements of the Pump$mart program were examined in the survey. Responses were requested regarding the number of allowed interruptions, the length of time per interruption, and the amount of rebate credit. The results confirmed that the informal research

conducted on and by board members with farming interests was accurate. In fact, the survey responses regarding program parameters were so positive that no changes have been made since the pilot program. As a true testament to the soundness of the program design, not a single farmer has bypassed an interruption event – a total of 1,520 pump-events without a single request to bypass. Further, only one farmer has elected to leave the program and that was due to a special circumstance: The farmer is no longer irrigating the ground and has elected to include the ground as part of a state and federal program allowing him to transfer the water rights to another area with a less critical water situation.

Lessons Learned

1. Judicious Use

Due to the availability of capacity, Midwest Energy has not pushed the limit on interruptions in any irrigation season. This has been a mixed blessing: It has allowed farmers to meet their watering requirements despite extraordinarily hot and dry growing seasons. However, it has painted an overly bright picture. Farmers are expecting far fewer interruptions than allowed by tariff.

In additions to farmer expectations, the Company needs to learn more about the dynamics of the system load and the resulting load shape. Careful timing – staging – of an event is important to maximize the value of DR. As an example, if an interruption had been scheduled at the time of the system peak, it would have resulted in a reduced peak, but the time (and possibly the day) of the peak would have changed. Immediate (same day) analysis of the system load shape and the Pump$mart (or other program) interruption results could minimize the risk of "peak shifting" and thereby maximize the value of the DR for true peak reduction.

2. The Value of a Third Party

Midwest Energy is a tiny utility compared to most utilities involved with DR. Yet, the load growth for small utilities greatly exceeds that of larger utilities. DR potential is relatively high, but expertise and the ability to hire staff dedicated to DR is lacking. Further, although irrigation load shapes and peak implications are intuitively obvious, it has always been difficult to reach the agricultural sector with utility programs for a number of reasons including the fact that energy costs always take a back seat to crop productivity. As a partner, EnerNOC brought a number of benefits to the table and made the program possible.

a. EnerNOC brought experience working with utilities and the agricultural sector.

Working with farmers is different than any other customer class. EnerNOC has a history reaching this hard to reach sector and the experience with other irrigation interruption programs is what initially enticed Midwest Energy to partner with EnerNOC. Further, their marketing expertise with farmers has helped the program grow so rapidly.

b. Midwest Energy needed a turnkey solution which made real economic sense in terms of minimizing staffing and maximizing expertise.

This program is a Midwest Energy program – and is viewed by farmers that way. Despite the turnkey solution offered by EnerNOC, the program is tailored specifically to meet Midwest Energy's needs. Program parameters are specific to Midwest Energy. Operational characteristics are driven by Company needs. The Customer relationships are managed by Midwest Energy. Midwest Energy has been able to tailor every aspect of Pump$mart to meet its needs.

c. EnerNOC's advanced technology is a key factor in the success of the program.

The advanced technology takes three forms: First, the Lodestar control devices are state of the art control devices developed by M2M Communications (a part of EnerNOC). The technology has proven extremely reliable with operational success very close to 100% during each of the 12 interruptions to date. In other words, if the pump is running, the control technology will shut it off and turn it back on as the requests are made.

Second, with EnerNOC's DemandSMART application, Midwest Energy can monitor load shed results in real time and gage the success of stopping and restarting irrigation equipment very quickly. It is critical for Midwest Energy to be able to prove the capability of the DR system whether "the button is pushed" or not. The DemandSMART application has greatly simplified this process and allows the utility to incorporate actual or "deemed" capacity savings for the purposes of satisfying regulatory requirements and qualifying the DR as a resource. Conducting Evaluation, Measurement, and Verification while utilizing EnerNOC's utility experience has proven invaluable.

Finally, EnerNOC's dependable Network Operations Center has performed flawlessly. Midwest Energy has elected to have EnerNOC dispatch pump interruption and restart, though the dispatch can be scheduled and executed by internal personnel. Careful communication protocol with EnerNOC has worked well, eliminating the need for Company personnel to be overly involved in the tasks involved in dispatching an event and freeing up time for internal communication and results monitoring.

3. Marketing Lessons

a. Cost savings and credits alone won't determine participation.

The utility bill is small in comparison to the total cost of production. For farmers that were able to control their pumps during periods of on-peak rates, the net savings (including credits) are zero by switching to the Pump$mart program compared to the TOU rate. However, most farmers on the TOU rate do pump for a significant number of hours on-peak. The ability to run a significantly higher number of hours while paying no on-peak rates drives participation. In other words, providing customers flexibility to run as needed without penalty matters. With

Pump$mart, the maximum number of controlled hours is (at most) 3.6% of the summer hours. It hasn't been more than 1% in any of the three years since the program started. On-peak TOU rates could be in place for almost 25% of the summer hours. Even with the temperature-dependent option, the on-peak rates usually constitute over 10% of the summer hours. Again, the flexibility to run more hours as needed without penalty is appealing to farmers.

b. Value-Added Services Matter

Farmers are not slow to adapt new technologies. For example, GPS systems have been guiding farm machinery for years with more precision than possible by hand. The ability to monitor and control pumps remotely and by a smart phone or laptop computer is valuable. Many farmers live significant distances from the fields they farm. Checking pump status remotely saves fuel and protects crops. Several farmers commented that their pivots suffered a lighting strike and weren't operational. The monitoring capability informed them there system was out and prevented them from losing time and possibly crop productivity by allowing them to rapidly address problems that are now known immediately, and ultimately give them the ability to meet their watering requirements.

c. Timing Matters

Marketing the program to farmers immediately after the growing season proved ineffective. Instead, farmers begin gearing up for the next season in the first two months of the year. By far, marketing to farmers early in the calendar year has proven more successful than marketing late in the prior year.

Conclusions

Midwest Energy has proven the ability to reach the hard to reach in demand side management. In particular, through a partnership with EnerNOC, Midwest Energy has developed a remarkably effective DR program called Pump$mart. With Pump$mart, Midwest Energy has:

1. Proven ability to reduce peak demand by over 5.2% in only three years of program existence.
2. Lowered peak capacity requirements by over 15 MW (Pump$mart alone) plus the associated reserves (roughly 1.5 more MW) at a cost significantly below that of peaking generation.
3. Required less than one-half of a Full-Time-Equivalent (FTE) employee to administrate the Pump$mart program.
4. Generated high satisfaction levels with the program and with the Company.
5. Gained valuable expertise regarding load analysis that can be applied to additional DR programs.