Using More Energy Can Be a Good Thing: C&I Loads as a Balancing Resource for Intermittent Renewable Energy

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The Balancing Act: Bonneville Power and Wind Integration

Energy efficiency and load control have long been familiar to the industrial segment. Not only have industrial customers led the way in making energy efficiency synonymous with good business practice, they also participate in utility interruptible rates or in load control programs. Historically, these two concepts – energy efficiency and load control – have required only minimal overlap, in large part due to the manual, infrequent nature of load control events. But that is changing, as evidenced by the Bonneville Power Administration's (BPA) recent technology-enabled demand response pilots in the Northwest. The BPA pilots are a terrific example of industrial customers leveraging the same control systems that drive energy efficiency to provide additional value to the electric grid in the form of demand response. Importantly, these pilots provide a snapshot of the technology-enabled load control opportunities that will be available to industrial customers in future programs throughout the Northwest and beyond, opportunities that will be best served as industrial customers, their utilities, and third-party vendors work to integrate demand response and energy efficiency activities.

Bonneville Power Administration is a self-funded federal agency that markets wholesale electrical power from 31 federal hydro projects in the Columbia River Basin. BPA's service territory covers parts of Idaho, Oregon, Washington, Montana, and small parts of California, Nevada, Utah, and Wyoming. Within those eight states, BPA serves 142 utilities, most of which are municipal utilities, coops, and public power districts. BPA itself markets 13,000 MW of capacity – 11,000 MW of which is hydro – providing approximately one-third of the electric power in the Pacific Northwest.[1] For some utilities, BPA serves as a power wholesaler to meet only a portion of the utility's power needs, while the utility procures the remainder of the necessary power through its own generation or other sources. For other customers, BPA is a full-requirements provider.

BPA also operates and maintains the majority of the transmission system in the Northwest, and manages the balancing authority for an area covering parts of rural Oregon and Washington, and small segments of Idaho and Montana, representing over 10,000 MW of peak demand.[2]

As a national front-runner in the integration of renewable energy resources, BPA is in a position to serve as a leader for other regions adopting intermittent renewable energy sources at scale. BPA has historically met peak load requirements through the flexibility of the hydropower system. However, continued load growth, wind power integration, and fish operations are beginning to limit this flexibility for BPA and elsewhere throughout the Northwest.

[1] Bonneville Power Administration, "BPA facts", April 2013, http://www.bpa.gov/news/AboutUs/Pages/default.aspx
[2] Berwager, Sydney, "BPA Report on Wind Integration", NWPPA Power Supply Workshop, October 2011

The Challenge: Wind Integration Stretches Balancing Reserves

The pace of wind power development in the Pacific Northwest has exceeded BPA's projections. Today, BPA has almost 5,000 MW of interconnected wind, and will potentially add an additional 2,000 to 6,000 MW in the next few years. This is significant penetration for a region with approximately 39,000 MW of generating capacity. [3]

The region's wind development has been driven by (1) renewable portfolio standards (RPS) in Oregon, Washington, Montana and California with wind serving as a low cost renewable resource available in bulk; (2) federal and state financial incentives such as production tax credits (PTC); (3) historically quick site and permit approvals; and (4) the combination of rural economic benefits and green elements that lead to political support. As the balancing authority for a large portion of the service territory, BPA is responsible for ensuring a constant balance between load and generation within its system—even though the majority of the region's wind power serves load outside BPA's balancing authority, such as California. BPA studies suggest that the Columbia River hydro system may not be able to be used to maintain a balance between scheduled generation and load (for the projected amount of wind power. The result is a near-term need for new balancing tools.

The Need: Balancing Reserves & Load Shifting

In the most basic sense, system operators must ensure the constant balance between supply and demand on the electrical grid. BPA does this using resources known as balancing reserves. BPA schedules base load generation on an hourly basis, and uses three balancing reserve product-types to correct imbalances between forecasted supply and demand within a matter of seconds (regulation), minutes (load following), and on a sub-hourly basis (balancing).

BPA uses the hydro projects in the Columbia River Basin for regulation, load following, and balancing, collectively known as balancing reserves. These are ancillary uses of the hydro system, as the vast majority of the resource supplies base load. In general, the hydro system represents a fast, flexible and inexpensive supply resource.

The BPA hydro system can provide +/- 1,000 MW of balancing reserves and is approaching its limit. The influx of new wind resources leads to greater intermittency on the supply side of the equation, resulting in a need for additional balancing reserves. BPA wind integration analysis has indicated a potential need to increase regulation, load following, and balancing requirements. Among them, load following represents the biggest need, with forecasts recommending 210 MW of new capacity as the next 3,500 MW of wind capacity comes online within the BPA footprint.

The BPA hydro system balances many priorities beyond electricity. The federal agency is also responsible for ensuring that the hydro system meets U.S. EPA Endangered Species Act (ESA) requirements, and must prioritize other non-power requirements including irrigation and flood control. For example, during the spring runoff period when the reservoirs are full and the water is high, ESA rules prohibit BPA from spilling extra water over the dams to reduce hydropower generation, as doing so may increase nitrogen levels in the river and harm fish. As a result, BPA has to run water through the turbines, even if there is excess wind on the system. During such times (typically the middle of the night during the spring and early summer), if there

[3] Bonneville Power Administration, "BPA facts", April 2013, http://www.bpa.gov/news/AboutUs/Pages/default.aspx

is not enough load to use all of the hydro and wind generation, BPA faces a dilemma between curtailing the wind and compromising its ESA and flood control responsibilities. The search for an optimal solution has been a challenge for many parties in the region.

The Approach: Piloting Demand Response to Address Future Capacity Constraints

BPA is committed to finding new sources for balancing reserves, including demand-side solutions, particularly flexible loads that can respond quickly to signals to both add and reduce load, depending on the imbalance the utility is working to address. As BPA discovers cost-effective options, it may re-purpose some of the existing hydro resource for other uses.

The EnerNOC Utility Solutions team recently worked with BPA to evaluate demand-side solutions for balancing reserves needed to accommodate variable wind generation. They implemented two pilot projects to estimate the potential and performance characteristics of commercial and industrial (C&I) load following resources:

- Smart End-Use Energy Storage and Integration of Renewable Energy Pilot – In partnership with Ecofys US, Inc., the EnerNOC Utility Solutions team evaluated the load following characteristics of five cold storage warehouses across four utility territories by controlling compressors, evaporators, and other refrigeration system loads up and down.
- Commercial and Industrial Demand Response Pilot – In this project the EnerNOC Utility Solutions consulting team (formerly Global Energy Partners)supported the City of Port Angeles (a municipal utility on the Olympic Peninsula) efforts to enable a paper mill to provide up to 40 MW of load following capability.

Implementing Demand Response Balancing Reserves Pilots and Outcomes

Engaging Industrial Participants: The Pilot Implementation

Participating utilities, BPA and pilot implementers (EnerNOC, Ecofys, and others) worked together to recruit customers, coordinate technology implementation, verify system communications, and manage and monitor demand response events.

Recruitment process. Recruitment involved direct customer engagement, initially providing customers with an overview of project drivers and parameters before conducting a demand response audit of the facility's operations to better understand potential INC (equivalent to generation increases, so load decreases on the demand side) and DEC (equivalent to generation decreases, so load increases on the demand side) contributions. For those customers interested in participation, the project team worked with the customer to determine the appropriate level of participation, balancing the customer's potential demand response capabilities with their business needs. For refrigerated warehouses participating in the Smart End-Use Energy Storage and Integration of Renewable Energy Pilot, financial incentives were provided on a $/kW basis to enhance the customer value proposition.

In the City of Port Angeles pilot, financial incentives were not provided. Instead, the customer was motivated by the ability to provide value to the electric grid, was interested in experimenting with and helping prove the viability of demand response, and was able to tap into project funds to invest in controls programming and infrastructure. Customers were required to sign agreements to formalize their participation in each of the pilots and to document their performance commitments. This process required a significant amount of customer contact and a thorough legal review by both sides to ensure all concerns were addressed. Importantly, and consistent with successful C&I demand response projects in other markets, this level of engagement by the customer during the administrative phases of the deployment helps secure customer buy-in in advance of testing and event participation.

Target Industrial Segments

The two pilots enabled six participant sites representing two specific industrial market segments (Table 1). For purposes of testing and pilot activity, these participants were broken into two groups:

- Group 1 - Five refrigerated warehouse sites as part of the Smart End-Use Energy Storage and Integration of Renewable Energy Pilot: These sites were enabled with fully automated end-to-end load control (Auto-DR capabilities and were capable of responding to requests for decreases and increases in load as directed through a demand response automation server within 10 minutes. All Group 1 sites participated via Auto-DR; however due to the timing of this project only one of the sites participated via the open automated demand response (OpenADR) standard, an emerging standard for demand response control and communication.
- Group 2 - One large paper production facility as part of the Commercial and Industrial Demand Response Pilot: The paper mill was capable of responding to requests for decreases and increases in load from the demand response automation server (DRAS) within 10 minutes. The project implemented OpenADR communication protocols between the DRAS and the OpenADR software client resident at the plant's server. Due to business requirements, full automation of the load change was not tested. The site has operators monitoring the process 24/7 who reviewed and accepted or rejected any load reduction or load increase requests.

All of the industrial participants in Groups 1 and 2 provided bi-directional balancing reserves in the form of "INCs" (equivalent to generation increases, so load decreases on the demand side) and "DECs" (equivalent to generation decreases, so load increases on the demand side). Response times for these two groups were ten minutes, while the INC/DEC capacity varied by site.

Table 1. Targeted Industrial Sectors

Facility Type	Equipment Enabled	Load Control Measure(s)	DR Capability	Group
Refrigerated warehouse (five sites)	Ammonia compressors, evaporators	Raise or lower set point temperatures	Curtail and increase	Group 1
Paper production	Motors	Turn on or off mechanical pulping motors	Curtail and increase	Group 2

Technical requirements. All of the participants in Group 1 participated on an automated basis, with no customer intervention necessary to deliver load control. The high level system architecture was consistent across both pilots, with a utility generated dispatch signal (or proxy) transmitted via a demand response platform to a gateway or client device at a participating customer site, triggering automated response. This dispatch and control communication was tested in both open-protocol (OpenADR) and proprietary forms, depending on the pilot and customer facility. The specific hardware and software configuration also varied by pilot, as shown in the diagram below.

From a customer perspective, the two key technical requirements were actually quite simple: a pulse-capable utility meter, in order to capture interval energy usage data to demonstrate INC and DEC performance and the capability to automatically add and reduce load, through pre-programmed scripts on existing controls systems. For load increases (DECs) in particular, customers were expected to control loads with inherent operational flexibility or storage so as to shift usage, rather than to simply use more electricity. For example, a refrigerated warehouse that increased cooling in response to a DEC signal required less electricity following the end of the dispatch in order to maintain product temperatures. Otherwise, each customer had the flexibility to participate based on their existing control systems and unique business needs. For example, the refrigerated warehouse participants were notified of a dispatch signal via phone and email and had the option to over-ride. Absent any intervention, loads were controlled automatically through a signal to the gateway device at the customer facility, closing a switch to trigger a pre-programmed script on the warehouse's refrigeration control system. As a result, actual demand response performance was much more a function of the facility's control system capability than the demand response platform itself.

Group 1: Installed hardware and software. The high level system architecture implemented for demand response at Group 1 sites included: (1) a server for dispatching the event signal, and (2) a client located at each facility to monitor the signal and interface with the refrigeration control system.

In this project EnerNOC's Network Operations Center (NOC) was used to dispatch event signals to all but one of the facilities. The one exception received signals dispatched from a DRAS operated by Utility Integration Solutions (UISOL).

At each facility, EnerNOC installed a hardware device called an EnerNOC Site Server (ESS). The ESS is a two-way communications solution that (1) captures near real-time electricity consumption data on 1-minute intervals and (2) relays the event signals to the centralized refrigeration control system at the participating facilities. The ESS was typically installed in the electrical room at the facilities and was equipped to read and record electrical data through the use of KYZ pulse outputs provided by the utility meter. (KYZ pulse output is a technique in which one unit of energy/watt-hour corresponds to one pulse.) The ESS received event signals from the NOC or the UISOL DRAS, and sent electric energy and demand data to the NOC, by using secure communication protocols through a wireless (cellular) internet connection.

Group 2: Installed hardware and software. The configuration for the demand response system implemented at the paper production facility included the DRAS also operated by UISOL. The software client at the facility was developed by the site IT staff and ran on the plant's local area network (LAN).. The client monitored the DRAS for event information including duration and magnitude, and alerted operators, via the local control panels in the plant, once the 10-minute event notification was registered. Plant operators entered their planned response into the local control panel. The information was sent by the client to the DRAS. The operators then made the appropriate adjustments to the plant operations to meet the INC/DEC requirements. To be considered successful, the facility needed to adjust its demand within 10 minutes from the time the DRAS operator initiated the request. Plant demand data was continuously streamed, to the DRAS, to record the results of the load change.

For each participating customer, the technical coordination process included:

- Installation of a gateway device at the utility meter.
- Engagement with existing controls vendor (or selection of a new controls vendor) to design and program facility load control scenarios.
- Establishment of connectivity between the gateway device and the applicable building automation system (BAS), energy management system (EMS), refrigeration management system (RMS) and/or industrial process control system.
- Establishment of connectivity between the demand response platform (NOC or demand response automation server or DRAS) and the gateway device.
- Training on web portal for energy and event management and monitoring.
- Testing of system communication and control capabilities.

Reliable data communication is a critical component of any demand response infrastructure. The pilot projects monitored real-time connectivity to ensure that all participants were able to participate in events, that critical energy usage and performance data was being captured, and that load control signals were working properly. Devices not communicating with the NOC or DRAS or experiencing other technical difficulties were contacted immediately to troubleshoot issues, with a technician dispatched to resolve more complex challenges such as those involving network communications and client device operation.

Results

The pilots generally met project objectives by (1) demonstrating the ability for C&I loads to provide balancing reserves, (2) characterizing how customers actually provided the demand response, and (3) identifying barriers and opportunities to wider adoption.

C&I sites can serve as a demand-side balancing reserve resource. Specifically, as evidenced by the test results described below, the pilots successfully demonstrated that some C&I sites can in fact provide bi-directional 10-minute demand response for balancing reserves and demonstrated end-to-end dispatch communication and event execution.

- <u>Group 1</u> – Fifty-one load control events were dispatched across the five participating sites, with between two and four sites participating in each dispatch. Twenty-three of the dispatches called for load decreases (INCs) while 28 of the dispatches called for load increases (DECs). Between August 2011 and May 2012, the portfolio delivered 269 kW of average INC capability per site and 165 kW of average DEC capability per site. Between June and August 2012, the portfolio delivered 144 kW of average INC capability per site and 59 kW of average DEC capability per site. Decreased capacity during the summer months was both a function of increased operational activity in the facilities during the summer months, leaving less load available for control, and the fact that only three of five facilities were available for participation (one site was unavailable due to ongoing maintenance, another moved into a separate BPA pilot activity). Further compounding summer performance was a programming change at one of the participating facilities that negatively impacted DEC performance.

- Group 2 – This load demonstrated a capability to respond to 10-minute requests, and the ability to put a communication and an operational process in place at the plant to support 10-minute load response. Some of the load control events dispatched for the paper mill were rejected due to operational conflicts or maintenance. There were also some communications and other technology-related occurrences during the initial testing phase. For the dispatches that were accepted, four called for load decreases (INCs) while seven called for load increases (DECs). The paper mill delivered an average INC of 21.5 MW and an average DEC of 17.6 MW when participating.

Industrial customers participate in a variety of ways. As described in the Target Industrial Segments section, the pilots were also successful at characterizing how customers were able to provide bi-directional load control. Of particular note was the variety in how customers participated. Across cold storage sites, customers incorporated varying degrees of sophistication through interfaces with their refrigeration control systems. Additionally, Group 1 testing showed that both OpenADR and proprietary communication protocols through a Network Operations Center were capable of successfully delivering demand response.

Human element can be critical to industrial participation. The pilots demonstrated that even in the case of a large industrial site (in this case a paper mill) with sophisticated controls, the human element can be critical to demand response participation. While data collection, communication, and actual control protocols were fully automated, the large paper mill required human intervention in determining whether it would be appropriate to respond to a demand response signal. This intervention did not compromise the ability of the paper mill to provide value to the grid; on the contrary, it allowed the site managers to maintain sufficient control over their own business operations in order to participate in demand response activities.

Risk of setting a monthly peak demand needs to be considered. The pilot also provided key insights into potential barriers and opportunities for wider adoption. For all of the pilot sites, it became apparent early in the process that DEC dispatches would put customers at risk of setting a monthly demand peak, thus exposing them to demand charges that would significantly outweigh their participation incentive. For example, the monthly demand charge for the one participant in the Consumers Power (Oregon) service territory was $4.70/kW month, more than double the incentive that was available for Group 1 participants through the pilot. To mitigate this risk, the sites had to work closely with pilot implementers to re-program their refrigeration management systems to aim for DEC amounts significantly below their full potential.

As facility usage dropped during the winter months, the risk of setting a new monthly peak demand intensified. For example, at one facility in Richland, WA, peak demand that fluctuated between 500 kW and 900 kW during the August and September billing periods decreased to between 250 kW and 400 kW during the winter months. Such a narrow kW range meant that adding 100 kW of load at any given time introduced significant risk of setting a new monthly peak. Similar trends were observed in other refrigerated warehouse facilities, resulting in a decision not to test DEC dispatches unless the utilities would agree to ignore peak demand data recorded during test events. Fortunately, participating utilities were willing to work closely with the customers, BPA, and the pilot implementers to provide peak demand "immunity" as it related to monthly peaks set as a result of pilot testing.

Industrial customers well-suited for load control programs. The pilot also provided insight into the customer experience and business implications of demand response participation. Typically, industrial customers are well-suited to participate in load control programs for a variety of reasons, including their scale, their ratio of energy costs to other business inputs, and the presence of sophisticated control and other production information systems. The same was true of industrial customer participation in the demand response pilots. Following completion of the two pilots, all participating customers across all pilot groups indicated an interest in future participation in a demand response program in exchange for financial incentives. While all customers indicated an interest to participate in future DR programs, customer experiences, approaches, and considerations varied by site.

Maintaining flexibility to put operational needs first key to industrial customer participation. All customers were united in the need to put product and business priorities first. This became apparent in early pilot phases, as customers planned their demand response control strategies, and before and during event dispatches, when customers either took themselves out of the dispatch loop due to maintenance or business considerations or rejected dispatch signals. The need for such flexibility was not unique to these pilots – because the majority of the electricity available for load control is central to core business activities at most industrial sites (as opposed to a background load such as HVAC or lighting or signage), maintaining the flexibility to put operational needs first is paramount in order for industrial customers to participate.

Customer education key to securing involvement. Customers invested internal technical, administrative and operational resources to manage involvement in the pilots. Across all sites, multiple meetings (typically two or three, sometimes more) were required to educate the customer on program details and secure their involvement, answer questions, and begin preparations for enablement. While installation of the gateway device required only one or two days of onsite electrical work, communication testing and calibration (all provided by the program implementer), the programming of control systems and testing of load control strategies took several months. In some cases, customers invested in new control systems or upgrades, requiring additional time for basic installation and systems calibration before focusing on load control strategies. Throughout the enablement process, customer management monitored activities while on-site engineers and facility managers worked closely with program implementers, electrical technicians, and controls vendors to install hardware and program controls software before testing load control capabilities.

More closely linking event performance with financial incentives to enhance customer engagement. During the operating phase of the pilots, customer engagement varied. In some cases, customers were deeply engaged in each demand response event, acknowledging participation and managing activity throughout the event duration, with staff on call to manage any issues or anomalies. In other cases, the customer was alerted to events and had the opportunity to monitor activities, but typically waited for a pre-scheduled weekly or biweekly call with the pilot implementer to discuss site performance during dispatches and address any questions or issues. In still other cases, the customer took a more passive approach, receiving dispatch alerts but choosing to engage only if the pilot implementer alerted them to performance issues or other items requiring attention. For the industrial customers and the refrigerated warehouses, the more engaged they were in monitoring and managing event performance the more consistent their results. In the case of the refrigerated warehouses, the customers were able to see in real time if target load changes were being achieved and make adjustment or perform troubleshooting if they were not. Moving beyond the pilot phase, a program that more closely links event performance with financial incentives would likely engender greater customer engagement, in cases where INC/DEC events incur a financial cost. This is based on direct customer feedback through the pilot, including instances where the lumber mill, the paper production facility and the refrigerated warehouses were limited in their ability to participate due to financial concerns. Customer feedback regarding future opportunities echoed this sentiment, as does EnerNOC's experience working with customers across DR programs worldwide.

Lessons Learned: The Vision for DR as a Wind Balancing Resource

The results of the BPA pilots have been closely watched throughout the DR industry. As a result of a rapid nationwide increase in renewable energy resources, many utilities and grid operators throughout the world are exploring the feasibility of using DR to complement conventional tools for managing gaps caused by variability of renewable energy generation.

With such significant interest in this new and promising flexible tool, many of the lessons learned from the BPA pilots may be useful within the BPA region and elsewhere. The projects also assessed prospects for expanding the use of enabling technologies and the scalability of DR programs to contribute more significantly to the balancing needs of the growing renewable energy resources in BPA's balancing authority.

The following lessons may help inform future DR program design and development:

- Alignment of incentives – across these pilots the desire to provide DEC resources (increasing load) was constrained by the risk of setting new monthly peaks and incurring increased demand charges. It is necessary to align incentives and objectives to ensure that customer participation and behavior before, during, and after dispatch aligns with utility needs.
- Site loads vary by season. Refrigerated warehouses, for example, typically had less load available for DECs during the summer months when usage was already at high levels.
- Performance incentives must motivate facility staff to invest time and energy in program participation. Customer motivations vary. While some participate purely for community benefit or financial reasons, others benefit from new control and communications infrastructure that may come with program participation.
- Some maintenance occurs during planned outages and is therefore predictable. Other times unexpected equipment failure can immediately render a facility incapable of performing demand response events. At the paper making facility a critical motor, of significant size, failed without warning. Due to the motor's size it took several weeks to have the motor repaired and returned to service. No events were able to be scheduled until all maintenance was completed and production was able to catch up. In-depth engagement with the customer throughout the process is necessary to integrate DR

communication and control technology with customer systems and facilitate ongoing participation.

Identifying the Challenges and Barriers

In addition to the lessons specified above, several challenges should be considered by end-use customers and utilities when implementing DR programs for balancing purposes. These include:

- Limited market potential: The C&I pilot programs focused on just a few market segments that offered the greatest opportunity for balancing. These included refrigerated warehouses and pulp and paper processes. The reason these segments were selected for the pilots is that their loads are conducive to bi-directional load activities due to the presence of automated controls and the flexibility in their operations. While it is possible to anticipate other C&I segments, there will be many segments for which participation does not make technical or operational sense. Thus, while DR presents a promising opportunity to be a valuable element of the load following dynamic in the Pacific Northwest, it should not be looked at as an exclusive solution.
- Customer willingness and ability to participate: Using DR to provide balancing services needed for renewable energy integration requires end-use customers to respond frequently with little or no advance notification. Because of these complexities, customers may be more reluctant to participate in a balancing DR program than in a more traditional emergency or peak shaving DR program. This may limit the amount of load available for DR programs.
- Significant telemetry and data requirements: In order to ensure that the balancing tools are appropriately contributing to the grid operation needs, performance data must be monitored and recorded on a near real-time basis. This necessitates that appropriate telemetry equipment be installed at the customer site. In most cases, end-use customers currently are not equipped with adequate load metering equipment and do not possess the capability to stream load data at such rapid intervals.
- Customer technology maturity: Customers may need to have automation capabilities in their end-use systems in order to accommodate fluctuations in their power supplies without experiencing a noticeable impact on their operations. Many customers don't have these capabilities in their facilities or if they do, modifications must be made to accommodate the operational needs of the DR program.
- Potential conflicts with other DR programs: The same resources that are providing load following services could also be providing emergency/reliability DR capacity to avoid overloading the grid. If loads are providing demand reductions in response to grid emergency situations, those loads could not be simultaneously available to mitigate the impacts of variable renewable resources on the grid.
- Fast-response demand response: The pilot efforts demonstrated promising opportunities to utilize enabling technologies that allow end-use customers to utilize DR as a balancing tool. Where possible, automated demand response techniques were deployed using OpenADR protocols to ensure future compatibility and scalability. Should more of these types of programs be implemented, the use of fast response capabilities will be essential for the success. A majority of customers may not be able to respond fast enough to

accommodate quick response in both directions in response to intermittent conditions brought about by the wind resource without investing in automation. OpenADR protocols may allow these efforts can be scaled appropriately, without the risk that such assets may not be compatible with future software and communication protocols.

End-Use Segments for Balancing Reserves

Building on these pilot experiences, the following end-use markets are leading candidates to best meet the technical requirements for load following types of activities:

- Facilities with pumping loads (e.g., municipal wastewater, drinking water treatment, municipal waterworks, agricultural crop irrigation). These facilities often have storage capacity. This allows an increase in demand without losing the product of the work being done. By drawing from the storage it also allows a decrease in demand without impacting production levels
- Facilities with refrigeration/compressor loads (e.g., food distribution warehouses and food processing plants, arenas/stadiums/convention centers, data centers, hospitals, universities). A tolerable increase in temperature set point at these facilities can provide demand reduction. Conversely a decrease in temperature at the refrigerated warehouses results in increased demand. The benefit of colder temperatures is that the compressors can coast after the event is over, and the temperature set point is returned to normal
- Facilities with ventilating fan capacity (e.g., manufacturing with volatile organic compounds or particulate processes, automobile painting). In many cases the plants can be operated, with reduced but acceptable ventilation, by cycling fans or turning off a number of fans
- Targeted industrial processes (e.g., pulp and paper, cement, air products). These facilities often have storage capacity. This allows an increase in demand without losing the product of the work being done. By drawing from the storage it also allows a decrease in demand without impacting production levels

Insights for Utility DSM Program Managers and Industrial Energy Managers

Based on learnings from the BPA pilot programs, detailed assessments can now be made to identify the applicable end-use markets for balancing tools throughout the Northwest and beyond. This will allow utility DSM program managers to design programs and initiatives that will lead to expanded utilization of DR as a flexible tool. Importantly, these programs will leverage industrial control systems, introducing innovative concepts such as the provision of bi-directional balancing reserves. As energy efficiency practitioners continue to focus on maximizing efficiency in the industrial sector, often leveraging control systems, it will be increasingly important to consider the role these balancing reserves in the integrated demand-side management landscape.