Examining Synergies between Energy Management and Demand Response: A Case Study at Two California Industrial Facilities

April 30, 2012

Daniel Olsen, Sasank Goli, Aimee McKane
Lawrence Berkeley National Laboratory

Disclaimer

This report was prepared for Pacific Gas and Electric Company (PG&E) and Southern California Edison (SCE) and funded by California utility customers under the auspices of the California Public Utilities Commission. Reproduction or distribution of the whole or any part of the contents of this document without the express written permission of PG&E and SCE is prohibited. This work was performed with reasonable care and in accordance with professional standards. However, neither PG&E, SCE, nor any entity performing the work pursuant to PG&E's or SCE's authority make any warranty or representation, expressed or implied, with regard to this report, the merchantability or fitness for a particular purpose of the results of the work, or any analyses, or conclusions contained in this report. The results reflected in the work are generally representative of operating conditions; however, the results in any other situation may vary depending upon particular operating conditions.

Disclaimer

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or The Regents of the University of California

Acknowledgements

This work was sponsored in part by the Demand Response Research Center which is funded by the California Energy Commission (Energy Commission), Public Interest Energy Research (PIER) Program, under Work for Others Contract No. 500-03-026 and by the U.S. Department of Energy under contract No. DE-AC02-05CH11231. Additional funding was provided by Pacific Gas and Electric Company's Emerging Technology Program (CIEE Contract POPG03-L01, PG&E Contract 2500444914) and Southern California Edison Company's Emerging Technologies Program (CIEE Contract POSC01-L01, SCE Contract 4500435663).

The authors would like to thank Jonathan Burrows and Albert Chiu (both from PG&E) and Carlos Haiad and Jay Madden (both from SCE) for their support of this project. The authors would also like to thank David Albright (J.R. Simplot), Sean Higbee (Bentley Prince Street), Patti Boyd and Nick Leritz (both from Ecova), Kevin Collins (Strategic Energy Group), and Gerald Schneider (Lockheed Martin) for their contributions to this report.

Table of Contents

Disclaimer i
Acknowledgements ii
Executive Summary 1
Introduction 2
  Energy Management 2
  Demand Response 2
Bentley Prince Street 4
  Facility Description 4
    Overview 4
    Key Equipment and Processes 4
    Energy Management and Demand Response History 5
  Energy Management Activities 6
    Mid-Project Personnel Changes 7
  Enablement of Demand Response Capabilities due to Energy Management 8
    Improvement in Technical Capabilities 8
    Improvement in Operational Awareness 8
    Improvement in Energy Management Capabilities due to Demand Response 9
J.R. Simplot 10
  Facility Description 10
    Overview 10
    Key Equipment and Processes 10
    Energy Management and Demand Response History 11
  Energy Management Activities 11
  Enablement of Demand Response Capabilities due to Energy Management 13
    Improvement in Technical Capabilities 13
    Improvement in Operational Awareness 13
Discussion and Conclusions 15
  Gap Analysis 15
  Applicability to Other Facilities 15
  Recommendations 15
  Conclusions 17
Glossary 18
References 19

Executive Summary

This study was conducted to determine if the process of developing and maintaining an energy management system improves an industrial facility's capabilities for demand response. An energy management system is a set of procedures, documents, and records designed to help an organization improve its energy performance over time. Organizations and facilities use energy management systems in an iterative process to plan, measure, monitor, and modify their energy use and consumption, with the goal of continual improvement. Continual improvement is based on comparing current performance to past performance, to ensure that energy performance improvements from capital projects and operational changes are sustained and that new opportunities for improvement continue to be identified and implemented.

Energy management can include actions not only to improve energy efficiency, but also for load management and demand response. Energy management in industrial facilities is generally more complex than in commercial buildings due to the range and type of industrial energy systems and processes. Demand response (DR) refers to a set of strategies and systems used by electricity consumers to temporarily reduce their electrical load in reaction to electrical grid or market conditions. There exist a wide range of DR programs offered to consumers and many ways for the consumer to achieve the desired demand reduction. Both DR and energy management have been seen to be effective tools in improving energy utilization, but the relationship between the two has not yet been demonstrated.

To examine this relationship, a carpet manufacturing facility and a fertilizer manufacturing facility already participating in utility-offered energy management programs were recruited to participate in the study. The facilities were visited by Lawrence Berkeley National Laboratory researchers and key personnel were interviewed to investigate the energy management activities undertaken and how those activities impacted DR capabilities. For each facility studied, both technical and operational changes were made which were conducive to DR. The primary technical improvements that led to increased DR capabilities were the installation of variable frequency drives on process equipment. The primary organizational improvements were energy meetings, training, and other activities which raised awareness of the facilities' DR procedures. In addition, submetering installed for DR at one facility seems to offer additional capability for energy management due to an increase in available data on energy consumption.

Several additional opportunities for demand response exist, but there are barriers to their implementation. Although opportunities for variable frequency drives to contribute to demand response were identified, they are not being implemented due to either a lack of controls, inadequate payback, or perceived process inflexibility. Shorter duration, quick response demand response activities are also possible with appropriate utility programs and enhanced utility-to-customer communication infrastructure. Many of the changes that were planned, implemented, or identified at the two facilities are applicable to other facilities as well, suggesting that the adoption of energy management systems at other facilities could also lead to improvements in demand response capabilities. This nexus of energy management and demand response could be encouraged by combined utility and market-based program offerings, government incentives, and the inclusion of demand response in building codes.

Introduction

Energy Management

Energy management is the process of planning, measuring, monitoring, and controlling the energy use of an organization or facility. This process is intended to lead to continually increasing energy performance, with all of the associated benefits. An energy management system is a framework of procedures, documents, and records used to ensure effective energy management. An energy management system (EnMS) should not be confused with an energy management control system (EMCS): the former is a set of operational measures designed to help a facility make effective choices about its energy use and consumption, while the latter is the equipment and software that carry out these choices. In recent years, several standards for energy management systems have been developed and released, including: ANSI/MSE 2000, developed by Georgia Institute of Technology and released in 2000; EN 16001, developed by the European Union and released in 2009; and ISO 50001, developed by the International Organization for Standardization (ISO) and released in 2011. ISO 50001 is based on the Deming Plan-Do-Check-Act cycle (seen in Figure 1). Soon after its launch, ISO 50001 became the best-selling standard in ISO history (International Organization for Standardization 2011b). Key elements of an EnMS conformant with ISO 50001 are:

- An energy policy
- A cross-divisional management team led by a management representative
- An energy planning process
- An energy baseline
- Identification of energy performance indicators
- Energy objectives and targets
- Action plans to improve energy performance
- Operating controls and procedures
- Measurement, management, and documentation
- Internal audits and periodic reporting of progress

Superior Energy Performance (SEP) is a facility certification program, developed under the guidance of the U.S. Council for Energy Efficient-Manufacturing (U.S. CEEM). SEP certification is based on implementing an EnMS conforming to ISO 50001 with additional requirements for meeting a specified minimum third-party verified energy performance improvement within three years. The first five pilot facilities gained certification in 2011 with energy performance improvements of 6.5% to 17% over a period of two to three years (U.S. CEEM 2012). One of the facilities in this study, Bentley Prince Street, is participating in a national SEP demonstration program involving 40 industrial facilities.

Continuous Energy Improvement (CEI) is another energy management system program, pioneered by the Northwest Energy Efficiency Alliance and subsequently extended to other jurisdictions. It contains many of the same energy management elements as SEP, including following a Plan-Do-Check-Act cycle and requiring top management commitment, but does not require adherence to an energy management standard or specified energy performance improvements. One of the facilities in this study, J.R. Simplot, is participating in PG&E's version

of the Continuous Energy Improvement program. Through the program, PG&E provides J.R. Simplot with design and technical support necessary to achieve effective energy management.

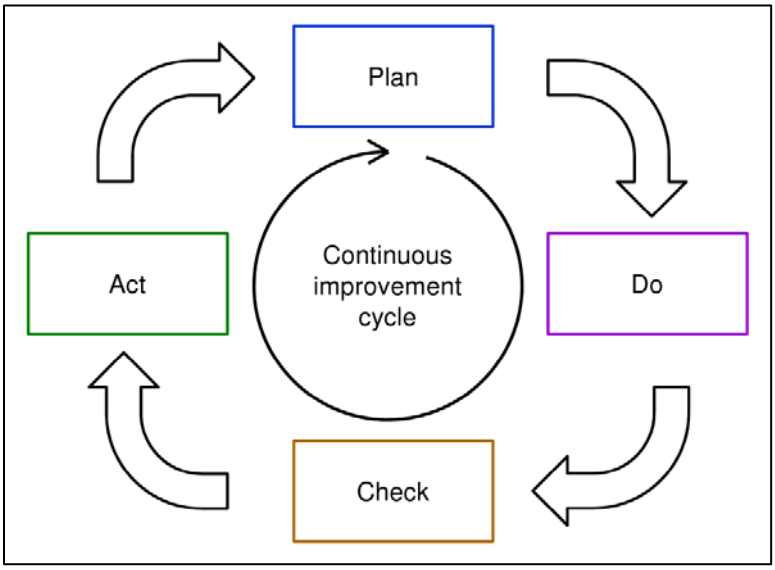

Figure 1: The Plan-Do-Check-Act cycle for continuous improvement

Demand Response

Demand Response (DR) refers to changes in electrical load at a specific site or aggregated group of sites in reaction to electrical grid conditions. It is one of many measures which can reduce peak demand, as seen in Figure 2. DR can take the form of direct control of loads by the electrical utility or grid operator, customer load control requested by grid operators as a grid reliability measure, or customer load control as a result of the price of electricity. A load reduction that is rescheduled at another time is known as a load shift, while a load reduction that is not rescheduled for another time is known as a load shed.

The benefits of DR to the electrical grid include a better utilization of existing infrastructure, the avoided costs of operating the most expensive generators, and increased grid reliability. Participants in demand response programs often receive monetary incentives for installing technology that enables demand response, and further incentives for their participation in demand response events.

DR can be implemented with varying degrees of advance notice to participants, from one day's notice to just seconds. Length of DR events can vary from several hours to just fifteen minutes and degrees of automation may vary from manual to fully automated. Fully automated demand response enables load reductions to occur without human intervention, but offers customers the ability to opt-out of scheduled events if desired (Piette et al. 2006). The logistics and incentives of demand response programs offered to electricity consumers vary widely across utilities and grid regions. A summary of demand response offerings and enrollment can be found in the Federal Energy Regulatory Commission's *Assessment of Demand Response and Advanced Metering* (2011).

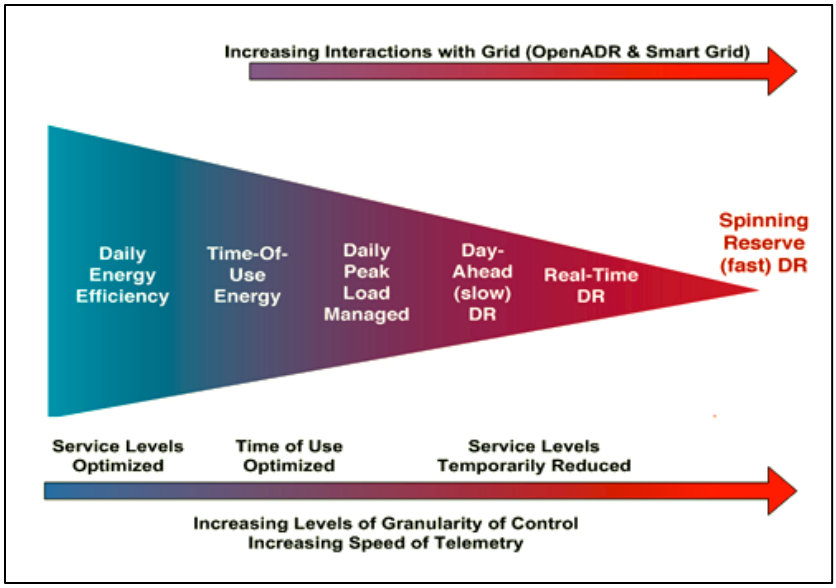

Figure 2: A diagram showing the role of demand response in peak load reduction (Source: Demand Response Research Center 2012)

Implementation of an energy management system has been found to be effective in increasing energy efficiency in industrial facilities (Ferland et al. 2009, Gordić et al. 2010, Wessels, 2011) but no link has yet been demonstrated to demand response capabilities.

Energy management and demand response use some of the same processes and technologies to effect their desired changes in energy use. Dynamic pricing programs, which include permanent load shifts such as time-of-use (TOU) pricing as well as more variable programs such as critical peak pricing (CPP) and real-time pricing (RTP), have been seen to produce an average savings of 4% compared to baseline energy usage (King and Delurey 2005). A Sacramento Municipal Utility District (SMUD) program aimed at reducing both energy consumption and peak period demand in small office and retail businesses achieved a 23% savings in weather-adjusted energy consumption and a 20% reduction in average peak load on critical peak event days (National Action Plan for Energy Efficiency 2010). The intention of this study is to determine if energy management actions improve an industrial facility's capabilities for demand response, and if so, in which ways that improvement is generated.

Two industrial facilities in California participating in energy management programs were approached and agreed to participate in this study. Each facility was being assisted in their energy management activities by one or more consultants, supported by their respective utility company. Researchers from Lawrence Berkeley National Laboratory (LBNL) visited each facility for a process walkthrough and corresponded with the facility engineers and consultants to determine what technical and operational changes were being made as part of energy management activities. This report details those activities and findings from these two facilities, a carpet manufacturer in Southern California and a fertilizer manufacturer in the Central Valley. Since the study focused on the industrial sector, the office section of each facility was excluded from analysis. As the timeframe of the LBNL study was limited, some findings are related to activities which are planned, but not yet completed.

Bentley Prince Street

Facility Description

Overview

Bentley Prince Street's manufacturing facility is located in Industry, California. It employs approximately 300 people on the plant floor and 40 in the attached office. Yarn, dye, and backing material are brought into the factory and manufactured into rolls or tiles of carpet (seen in Figure 3). There are several stages of intermediate product that are often stored in the factory until further processing, and there is enough storage for several days' worth of production. Rolls of intermediate product are transported around the facility by forklifts.

At the company level, Bentley Prince Street has pledged to eliminate any negative impact that the company has on the environment by the year 2020 (Bentley Prince Street, 2012), and the factory building is certified at the Silver level of the Leadership in Energy and Environmental Design (LEED) rating system.

Figure 3: The tile line at Bentley Prince Street

Key Equipment and Processes

A process flow diagram is shown in Figure 4. Most of the equipment is run for one shift per day. The tufting machines, which attach yarn to the carpet primary backing, run 24 hours per day, 6 days per week, as this process is a potential production bottleneck. There is no centralized control of equipment: equipment groups are controlled by local operator stations. There are several rooftop HVAC units serving office space and many ventilation fans in the roof of the factory area, but each of these is controlled individually. The most significant energy uses for the factory are its boilers, the tile line, the broadloom coater, dryer, and continuous dyeing line. There are three utility meters supplying power to the plant, with no intentional grouping

of equipment to meters. The plant's total utility demand peaks at approximately 1750 kW in the morning, and falls to a minimum of approximately 350 kW at night.

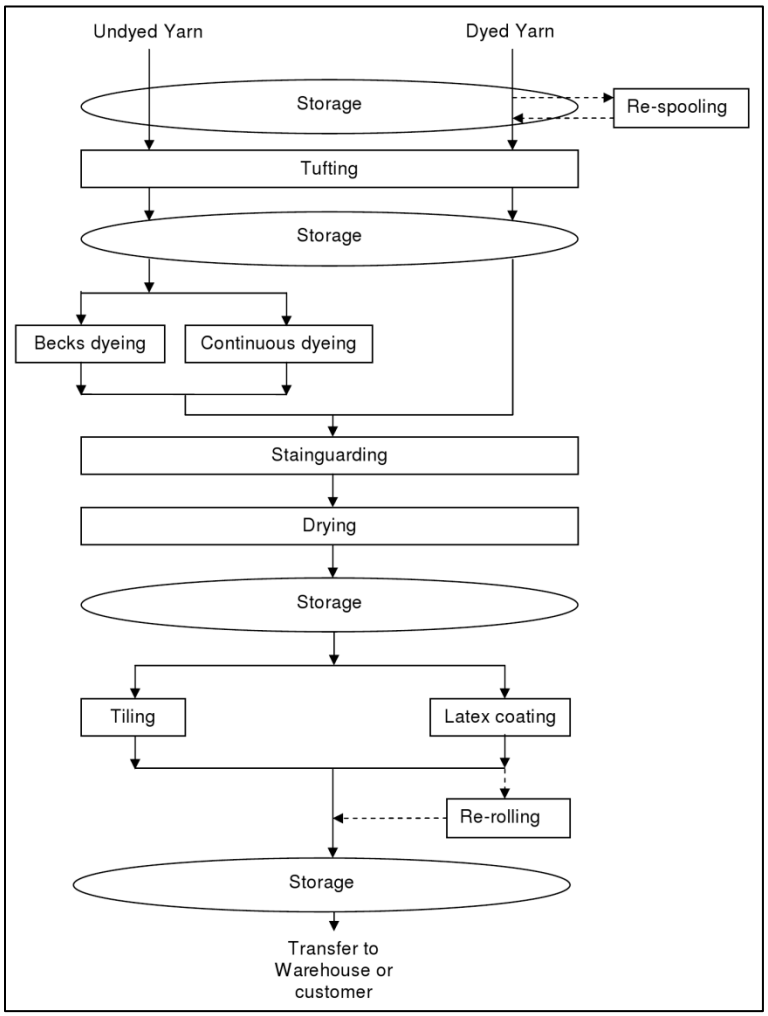

Figure 4: Process flow diagram for Bentley Prince Street's manufacturing facility.

Energy Management and Demand Response History

The plant had participated in several audits aimed at discovering energy efficiency and demand response opportunities. A motor assessment was conducted by Southern California Edison (the local electrical utility) and lighting, demand response, and process heating audits were conducted by independent contractors. The plant also has on-site solar photovoltaic panels, rated at 100 kW, which are used to self-generate a portion of the plant's electricity requirements.

The plant is participating in a Base Interruptible Program (BIP) electricity tariff. This tariff requires the customer to designate a firm service level—an amount of power that the customer always needs available. When a BIP event is called, the customer is contacted on a dedicated telephone line and must reduce their power demand below the firm service level for the duration of the event. If the customer fails to reduce their demand below the firm service level, they are subject to a financial penalty. In return, the customer receives credits to their bill based

on the difference between their average demand and the firm service level. Therefore, the more flexible a customer can be with their power demand, the less each unit of energy costs them. The firm service levels designated for Bentley Prince's three electrical meters are 25 kW, 75 kW, and 150 kW. Bentley Prince Street's tariff also incorporates time-of-use pricing, but this is not taken into account in the facility's production schedule.

Bentley Prince Street receives 30 minutes' notice before an event, and their strategy to bring their demand below the firm service level is to cancel production for the event day, shut off nearly all process equipment, and send employees home. There had been one BIP event to which the plant had failed to respond, resulting in a large fine. In an effort to prevent this from happening again, the plant engaged Powerit Solutions, a controls vendor, to install and configure an automated demand response (Auto-DR) system, incentivized by Southern California Edison. The Auto-DR system was estimated by Powerit to be able to shed an average of 907 kW from Bentley Prince Street's peak load, and also included several submeters for major equipment, improving the plant's knowledge of equipment electrical demand. The idea to install an Auto-DR system was concurrent with the beginning of energy management activities.

Energy Management Activities

Bentley Prince Street is participating in the California demonstration of a facility-level certification program known as Superior Energy Performance (SEP). The Superior Energy Performance program affirms that a facility has developed an effective energy management system aimed at continual improvement in energy performance and has achieved third-party verified energy performance improvements that meet a specified minimum. SEP is based on ISO 50001, with additional requirements for energy performance achievement. As part of the SEP demonstration, Bentley Prince Street received assistance in implementation of their energy management system from consultants, supported by Southern California Edison. Personnel responsible for sustainability and ISO compliance also attended SEP training workshops, supported by the U.S. Department of Energy, in April and November 2011. These workshops provided information on ISO 50001, the SEP program, and how to achieve, maintain, and measure energy performance improvements. A third workshop is planned for April 2012.

Bentley Prince Street's energy management team instituted monthly energy team meetings, developed an energy policy and an energy manual, and conducted an energy balance and a review of their significant energy uses. Demand response was included as a topic of discussion in the energy team meetings. A training session on DR software and tools was also attended by some team members.

In August 2011, LBNL researchers and the consultants assisting the facility with SEP implementation conducted a walkthrough of the Bentley Prince Street facility and discussed potential energy management and demand response opportunities with the Plant Engineer. Opportunities included:

- A whole plant lighting retrofit
- Retro-commissioning and/or improved control for HVAC system
- Installing variable frequency drives (VFDs) and controls on motors for:

    - Becks dye tank agitators (eighteen motors, 5 hp each)
    - Dryer combustion and ventilation blowers (ten motors, 25 hp each)
    - Cure over combustion blower (eight motors, 25 hp each)
    - High use tufting machines (twenty-six motors, 25 hp each)
- Assessment of process steam efficiency for continuous and batch dyeing
- Implementing steam trap and compressed air maintenance procedures
- Insulating exposed steam piping
- Installing combined heat and power (CHP) generation
- Controlling the HVAC system, becks dye tank motors, latex coater, yarn re-spooling, continuous dye line, air compressor, and/or forklift battery chargers for day ahead or shorter term DR
    - The fourteen battery chargers could contribute up to 240 kW of load shift in a DR event
- Optimizing the plant's operational schedule to take advantage of time-of-use energy costs
    - Plant personnel estimated that 700 kW could be shifted off-peak

Projects completed or planned since SEP participation include:

- Installation of more efficient boilers for the continuous dye line and becks dye tanks
    - The old boiler is rated at 36 MMBTU/hour, and was replaced by five 2 MMBTU boilers
    - Expected savings of $104,000/year
- A new 100 horsepower VFD-controlled air compressor
    - Expected savings of over 220,000 kWh/year
- Upgraded lighting for exterior and storage areas
    - Expected savings of over 55,000 kWh/year
- Commissioning of an Auto-DR system
- Installation of a CHP generation system designed to supply 455 kW of electricity and 455,000 BTU/hour of thermal energy

Mid-Project Personnel Changes

In September 2011, the Plant Engineer unexpectedly left Bentley Prince Street. Though there was some DR knowledge remaining with the energy team, the remaining members of the team were not as familiar with the DR aspects of the company's energy management system as was the departed employee. As a result, they estimated that tens of thousands of dollars were expended in the months following his departure on energy use which could have been avoided. Since then, actions associated with implementing the EnMS, such as energy meetings and documentation, have led to increased awareness of energy management and DR projects both within the energy team and within management, and the team expressed the opinion that this has increased the reliability of Bentley Prince Street's DR participation.

Enablement of Demand Response Capabilities due to Energy Management

Improvement in Technical Capabilities

Bentley Prince Street's installation of an air compressor controlled by a VFD offers increased DR capabilities compared to a fixed-speed motor. If compressed air tanks are large compared to the plant's use rate of compressed air, a short-term shutdown or slowdown of the compressor may be possible without affecting end uses. Alternatively, if processes utilizing compressed air are curtailed as part of a demand response strategy, the power consumption of the air compressor should also decline. At partial flow, the power consumption of a VFD controlled fan or pump approaches the theoretical maximum efficiency and is more efficient than other flow control methods, as seen in Figure 7. The potential demand response shed could be as high as 75 kW if all compressed air usage can be curtailed. The same opportunities apply to other motors for which the plant has identified VFDs as an energy saving measure, which account for 1190 hp (over 885 kW) of rated power.

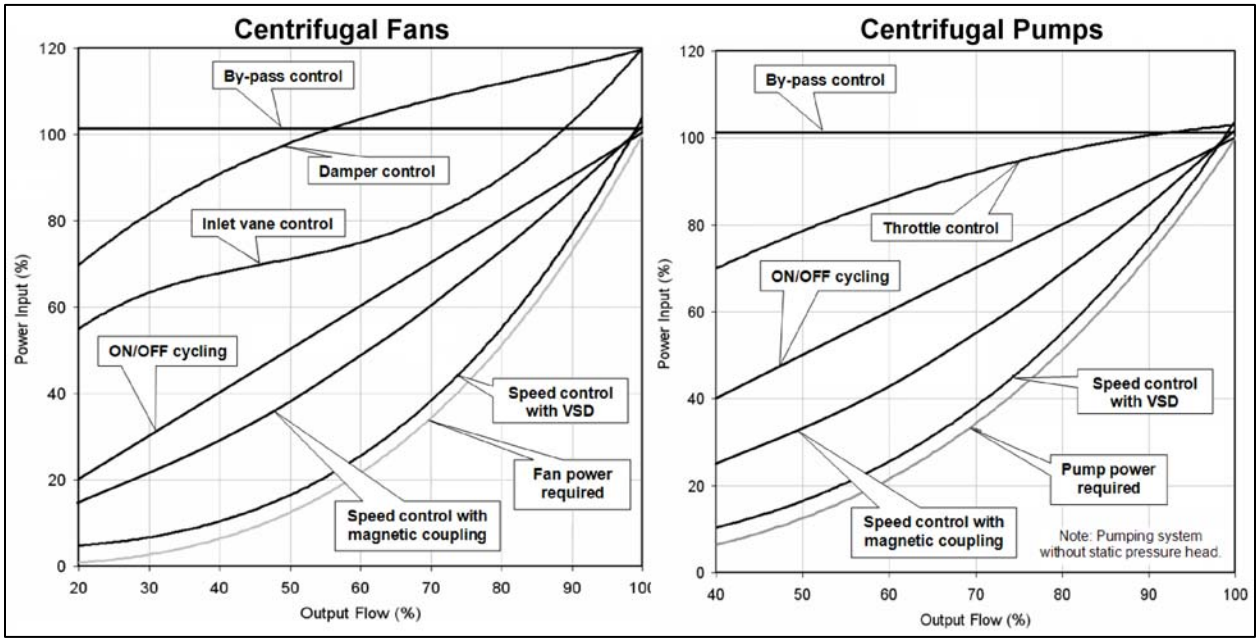

Figure 7: Comparison of a partial-flow power consumption in pumps and fans with various methods of flow control. Source: Ferreira 2009

Improvement in Operational Awareness

Augmenting the improvements in Bentley Prince Street's technical DR capabilities, there are also increased operational capabilities resulting from energy management activities. One of the projects on the facility's ISO 50001 energy project action plan is to schedule operations based on their time-of-use energy pricing. If implemented, this would in effect be a permanent load shift of up to 700 kW, reducing demand during the traditional peak period. Members of the energy team also attended training on DR software and tools. Inclusion of DR in energy team meetings and communication of DR procedures to management helped to ensure that DR strategies have adequate personnel support, even if one or more members of the energy team leave the

company. When a personnel change occurred in 2011, the energy management system was still in the process of being implemented, but since then it has become much more ingrained within the facility.

Improvement in Energy Management Capabilities due to Demand Response

In addition to energy management activities increasing the capabilities for DR, the converse also appears to be possible. The incentives that Bentley Prince Street received for their Auto-DR installation paid for several submeters within the facility. These submeters allow the facility to monitor in real-time the energy consumption of major process equipment. This information gives Bentley Prince Street more knowledge about the energy intensity of their processes and can give an early warning when energy consumption rises unexpectedly, helping to avoid wasted energy.

J.R. Simplot

Facility Description

Overview

The J.R. Simplot facility in Helm, CA (seen in Figure 5) is a manufacturer and distributor of liquid fertilizer, and a distributor of dry fertilizer. It operates on a continuous schedule, with facility shutdowns occurring annually and planned well in advance. The facility's most significant energy source is butane, which represents around 75-80% of the energy consumed. Electricity represents around 15-20% of consumed energy, natural gas represents around 5%, and gasoline and diesel combined make up less than 1%. The average facility electrical load is around 750 kW, with normal daily peak loads from 900-1000 kW.

Figure 5: The Helm facility of J.R. Simplot

Key Equipment and Processes

The Helm facility manufactures and sells calcium ammonium nitrate (also known as CAN-17), nitric acid, ammonium nitrate in two concentrations, and ammonium phosphate (also known as 10-34-0). The nitric acid plant consumes roughly 80% of the facility's total electric load. The nitric acid and ammonium nitrate plant are the most critical sectors of the facility, and are run continuously, shutting down only during annual facility shutdowns. The production of calcium ammonium nitrate and ammonium phosphate is less essential, and their corresponding plants are run intermittently. The facility generally has good control capabilities for its processes, but controls are outdated in some areas such as the CAN-17 plant. Variable frequency drives (VFDs) are not widespread. In addition, some processes have safety and process stability considerations that reduce the ability of plant operators to make significant changes to operating parameters. Therefore, equipment in these process areas would not be able to contribute to demand response events. A process flow diagram of the facility is shown in Figure

6. The nitric acid and ammonium nitrate plants together make up about 80% of the facility's total electrical load (~600 kW) with the remainder coming from the offices, CAN-17 plant, and 10-34-0 plant.

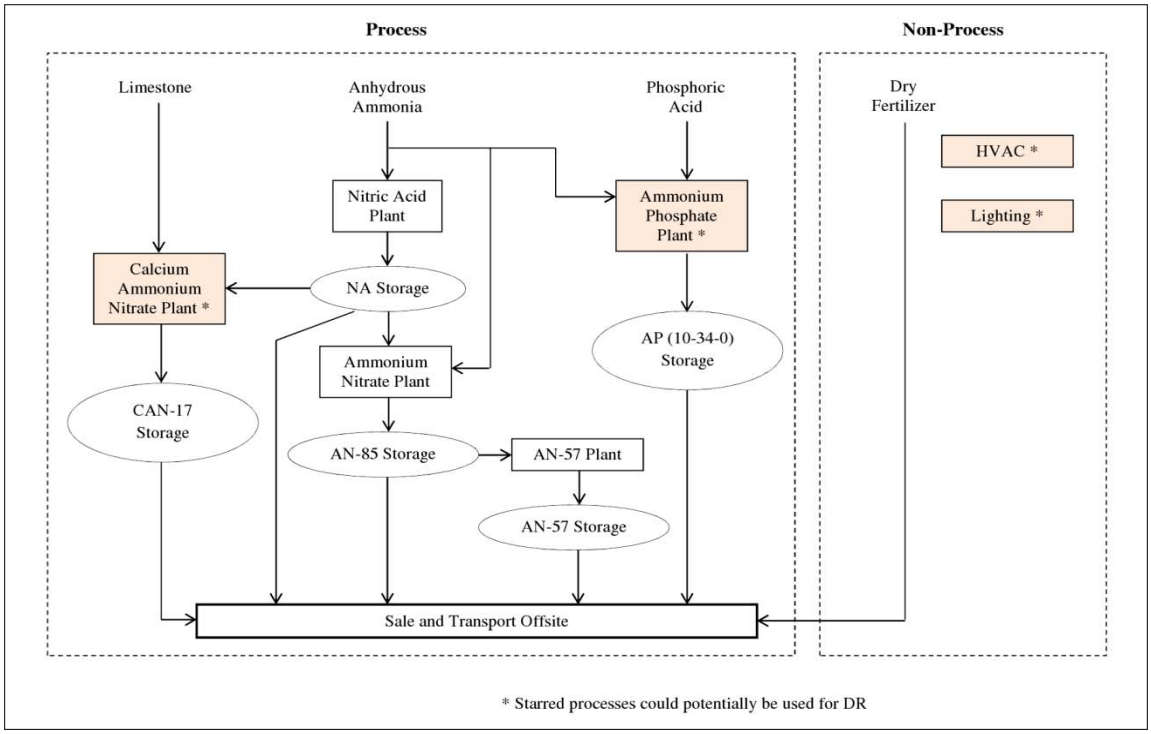

Figure 6: A process flow diagram of J.R. Simplot's Helm facility.

Energy Management and Demand Response History

At the corporate level, J.R. Simplot has made a commitment to a 25% reduction in the energy intensity of their products by 2020, compared to a 2010 baseline. The Helm facility began participating in PG&E's Continuous Energy Improvement (CEI) program in early 2010. The CEI program offers assistance in implementing an energy management system to facilities whose management has committed to supporting system implementation. In addition, the facility recently received a DR audit, conducted by a third party aggregator. As a result of this audit, the facility is currently in the testing phase of a DR program. The program being tested provides day-ahead notice of Auto-DR events, and allows the facility to opt-out of events if desired. The facility had also participated in DR in the past, but no details of the participation were recorded, or conveyed to current employees.

Energy Management Activities

Through the CEI program, a consultant was hired by PG&E to help the facility implement and maintain an energy management system. As part of this implementation, the facility:

- Developed an energy policy and included the policy in orientations for new employees

- Established a baseline energy usage against which performance improvements can be measured
- Established key performance indicators (KPIs) and tracks their progress[1]
- Tracked capital, non-capital, and behavioral projects and activities
- Held regular Energy Team meetings with appropriate representation of the organization
    - Meeting topics included: updates on KPIs, energy brainstorming, project updates, energy assessment updates, and awareness updates.
- Implemented a facility energy awareness campaign which included periodic KPI updates
- Participated in DOE energy efficiency training for compressed air, fan, steam, pump, and motor systems
- Included energy topics in safety trainings
- Improved its preventative maintenance practices
- Implemented a leak tag program

The facility was the subject of an Integrated Energy Audit by PG&E, conducted by a consultant from Lockheed Martin, which began in fall 2011. The Lockheed Martin consultant assessed the potential for energy performance improvement projects which had the potential to receive incentive payments from PG&E and worked to secure those incentives. After project completion, Lockheed Martin will validate the energy savings achieved to ensure that they meet expectations. As part of the assessment, temporary metering of the electricity consumption of the facility's equipment was undertaken.

Researchers from LBNL also conducted a facility walkthrough and discussed the potential for energy efficiency improvements and demand response participation with the facility engineer, the CEI consultant, and the Lockheed Martin auditor. Projects completed or planned for implementation included:

- Seven pump projects, consisting of replacements or control upgrades, all of which will have VFDs
    - Estimated savings of 390,000 kWh/year
- A replacement of several maintenance shop heaters with a more efficient design with timers
    - Estimated savings of 1,500 MMBTU/year
- A lighting retrofit with automatic controls
    - Estimated savings of 170,000 kWh/year
- Surveys of the facility's steam and compressed air systems
    - These resulted in an inspection and rebuild of the facility steam turbine
- An improved combustor catalyst was installed

Other projects with identified potential included:

[1] KPIs are functionally similar to Energy Performance Indicators (EnPI)

- Solar power generation
- Cooling tower upgrades
- Improved metering and calibration for electricity, water, butane, and compressed air
- Demand response capabilities: either manual, automated, or a combination of the two
- VFDs for many of the facility's motors
- Upgrades to the controls for the CAN-17 plant
- Upgraded air compressor and dryer
- Lighting upgrades with occupancy sensors or timers

These process changes resulted in a 2011 energy intensity (measured in MMBTU per ton of nitric acid manufactured) that was 27.6% lower than the facility's baseline, which was the average of the years 2006-2009. This translated to over $750,000 saved in avoided energy costs for butane alone. Pump and lighting upgrades are projected to save over $70,000 annually in avoided electricity costs.

Enablement of Demand Response Capabilities due to Energy Management

Improvement in Technical Capabilities

Many pumps at the facility are currently controlled via throttling valves, which are less energy efficient than pumps controlled by VFDs, as seen in Figure 7. Installing variable frequency drives not only saves energy, but also enables operators to reduce demand during demand response events if the pump flow can be temporarily reduced. Even in cases where VFDs must closely match downstream conditions, the installation of VFDs can contribute to demand response when the process demands of the downstream activities are reduced. J.R. Simplot has some recirculation loops feeding downstream processes which must be continually pumped in order to prevent crystallization of process chemicals. Installing VFDs on these pumps would allow their demand to be reduced when downstream processes are shut down for demand response purposes.

Upgrades to the controls of the CAN-17 plant have been proposed with the intention of increasing plant efficiency during startup and shutdown. Facility personnel have indicated that the CAN-17 plant can be brought online or offline in 15 minutes without loss of product. If the CAN-17 plant can be controlled for DR events, it would be able to shift approximately 43 kW of running load, based on three weeks of submetering conducted as part of the PG&E energy audit. If the pump feeding the plant with nitric acid is equipped with a VFD, the lower demand from the pump VFD during CAN-17 plant shutdowns can augment the demand reductions from the CAN-17 plant itself. Similar capabilities may also exist at the 10-34-0 plant, but were not able to be quantified during the submetering period.

Improvement in Operational Awareness

The regular energy trainings, meetings, and reporting implemented at J.R. Simplot offer a forum where new activities affecting energy use, such as demand response, can be introduced and discussed. As demand response participation can help participants save on energy costs,

other energy cost saving activities can lead to increased demand response awareness. The facility engineer indicated that J.R. Simplot was looking to reduce their energy expenditures and that energy management and demand response were both tools to achieve that goal. In addition, temporary metering of the facility's electrical equipment was conducted as part of the Lockheed Martin audit and permanent metering is planned to be installed. The data gathered from this metering will allow the facility to more accurately determine the loads and duty cycles of the facility's equipment, information which is useful when assessing demand response opportunities or participating in demand response events.

Discussion and Conclusions

Gap Analysis

Despite the improvements in demand response capabilities at these two facilities due to energy management activities, there are still obstacles to achieving their full demand response potential. At Bentley Prince Street, the control system can monitor energy consumption of major loads, monitor operational status of some other loads, and shut down equipment in the case of a demand response event. However, this system does not have the capability to turn down equipment if a partial shed is desired. At J.R. Simplot, several new pump motors with VFDs have been installed, but these are not being controlled for DR purposes due to process concerns; the addition of storage reservoirs may be able to enable these loads to participate in demand response. By pumping into a reservoir before a demand response event, pump demand can be reduced during an event as the process is fed by pre-pumped fluid.

Expanding the portfolio of demand response programs in which the facilities can participate would allow them to more effectively use their load as a resource. More frequent, shorter demand response strategies may be possible at both facilities by participating in the ancillary services market. Ancillary services are support services used to maintain power system quality and reliability. Through the California Independent System Operator (CAISO) Participating Load Program (PLP), the ability of commercial and industrial facilities to participate in the ancillary services market via demand reductions has been demonstrated (Kiliccote et al. 2009). However, in order to participate in the program telemetry must be upgraded to ensure 4-second communication between CAISO and facility servers (CAISO 2007).

Applicability to Other Facilities

Though this study only covered two facilities, many of the DR-enabling energy management activities could also be undertaken at many other facilities. Upgrading constant speed motor drives to VFDs is common energy efficiency upgrade which allows motor electrical demand to be reduced without stopping the motor. Installing a CHP generation system enables a facility to begin generation during a DR event to reduce their net demand, or enables permanent load sheds if the system is usually running at times when DR events are called. The improvement in energy management capabilities due to Auto-DR installation, as seen at Bentley Prince Street, are also likely to apply elsewhere, as Auto-DR installations commonly include additional metering infrastructure which gives facility personnel insight into their energy usage patterns. The identification of demand response opportunities due to increased awareness of energy issues should also apply to a wide range of industrial facilities. Often there is no personnel tasked with minimizing energy costs, and these opportunities are commonly overlooked.

Recommendations

Since the practice of energy management and enablement of demand response seem to be mutually beneficial, efforts should be made to harness these benefits. The Environmental Protection Agency's *National Action Plan for Energy Efficiency* (2010) lists four ways in which

energy efficiency and demand response could be coordinated: combined program offerings, coordinated program marketing and education, market driven coordinated services, and building codes and appliance standards. Some of these recommendations are already in practice, but unrealized potential undoubtedly exists.

Demand response incentives can contribute significantly to reducing the payback period of a facility upgrade, sometimes paying for 100% of upgrade expenses (Faulkner & McKane 2010a & 2010b). By integrating the processes of discovering projects with both energy efficiency and demand response incentives, dual-incentive projects can be identified as such and project payback periods can be reduced, which will improve implementation rates. PG&E currently offers integrated energy audits, assessing both energy efficiency and demand response opportunities, to facilities with large loads. Including energy management recommendations in these audits could help to ensure that all identified opportunities are realized. Incentivizing the implementation of standards-based energy management systems would both reduce total energy and increase demand responsiveness. Increasing the ability of facilities to participate in the ancillary services market will also increase the incentive payments they can receive in return for demand response participation, which will improve the DR value proposition.

Some jurisdictions have already begun to include demand response in building codes. Stakeholders and authors of the California Energy Code have agreed to include Auto-DR capabilities, demand responsive lighting controls, and demand response thermostats as mandatory code requirements for new and retrofit non-residential buildings in the upcoming revision of the Title 24 building standards. Final approvals and publication are planned for 2013 (David Watson, personal communication 2012). The result of this inclusion is that industrial facilities retrofitting their buildings to reduce wasted energy will also gain the technical capabilities to participate in demand response, and facilities unaware of demand response will be introduced to the concept via the upgrades.

Market programs are also beginning to identify the synergy of energy efficiency and demand response. The LEED program is currently testing a pilot credit for demand response which rewards building owners or operators who participate in manual, semi-automated, or automated demand response (U.S. Green Building Council 2011). Industrial facilities attempting to gain LEED certification to showcase their building energy efficiency actions may begin to participate in demand response in order to earn this credit.

Further investigation into the relationship between energy management and demand response could take several forms. A larger sample of facilities undertaking energy management could be studied to determine the extent to which energy management activities lead to new demand response installations, or a large sample of demand response participants could be studied to determine if they are more likely to implement an energy management system. More data will become available for analysis as ISO 50001 and other energy management system standards continue to penetrate the industrial sector.

Conclusions

At Bentley Prince Street and J.R. Simplot, energy management systems were incorporated into the organization, which led to technical and operational changes. These changes, through both increased technical capabilities and increased personnel awareness, have resulted in increased capabilities for demand response. The technical changes most relevant to demand response were the installation or planned installation of VFDs on process equipment, while the most relevant operational changes were those that increased awareness throughout the organization of demand response opportunities and procedures. Additionally, there seems to be a link between demand response implementation and energy management capabilities, as shown by the submeters that Bentley Prince Street received as part of their Auto-DR system.

Several other changes could be made which would increase the ability of these facilities to participate in demand response. An increase in the control capabilities of both facilities would allow more granular control over facility demand, and an expansion in the portfolio of demand response programs offered by utilities would more closely match utility needs with facility resources. An increase in material storage within the process will enhance the flexibility of energy usage. These changes, as well as the ones which were already implemented, are likely to apply to many other industrial facilities.

The nexus of energy management and demand response could be encouraged in several ways. More comprehensive studies could be undertaken to validate that the findings from this study truly apply to other industrial facilities, as industrial processes and equipment are extremely varied. Utility and market programs offering incentives for either energy management or demand response can offer combined programs or keep programs separate but promote both through coordinated marketing. Governmental agencies could mandate that the organizations that they contract with must incorporate energy management systems into their operations wherever applicable. Further experience with standards-based energy management systems will yield additional insight into their ancillary benefits, and offer opportunities to more thoroughly investigate their relationship with demand response.

Glossary

Auto-DR	Automated Demand Response
BIP	Base Interruptible Program
BTU	British Thermal Unit
CAISO	California Independent System Operator
CEI	Continuous Energy Improvement
CHP	Combined Heat and Power
CPP	Critical Peak Pricing
DR	Demand Response
EnMS	Energy Management System
EMCS	Energy Management and Control System
hp	Horsepower
HVAC	Heating, Ventilation, and Air Conditioning
ISO	International Organization for Standardization
kW	Kilowatt
LBNL	Lawrence Berkeley National Laboratory
LEED	Leadership in Energy and Environmental Design
MMBTU	Million British Thermal Units
PLP	Participating Load Program
RTP	Real Time Pricing
SEP	Superior Energy Performance
TOU	Time of Use
U.S. CEEM	U.S. Council for Energy-Efficient Manufacturing
VFD	Variable Frequency Drive

References

American National Standards Institute. (2000). ANSI/MSE 2000 Standard. New York, N.Y., Adopted April 6.

Bentley Prince Street. (2012). Bentley Prince Street – Mission Zero. Retrieved from: http://www.bentleyprincestreet.com/sustainability/missionzero.aspx

British Standards Institute. (2009). BS EN 16001:2009 Energy management systems – Requirements with guidance for use. London, UK. Published July 2009.

California Independent System Operator. (2007). Participating Load Technical Standard. Revision No. 6.1, released February 26, 2007.

Demand Response Research Center. (2012). Demand Response Research Center. From http://drrc.lbl.gov

Faulkner, D. & McKane, A.T. (2010a). Food Processor Achieves Significant Energy Savings and Incentives by Installing Demand Control and OpenADR Solution [Case Study]. CEC/LBNL.

Faulkner, D. & McKane, A.T. (2010b). Refrigerated Warehouse Participates in Auto-DR, Saving Energy, and Receiving Incentives [Case Study]. CEC/LBNL.

Federal Energy Regulatory Commission. (2011). *Assessment of Demand Response and Advanced Metering*. Retrieved from http://www.ferc.gov/legal/staff-reports/2010-dr-report.pdf

Ferland, K., Brown, J., Meffert, B., Hake, D., Krawczyk, M., Mazza, M., & Waz, P. (2009). Proceedings from the 2009 ACEEE Summer Study on Energy Efficiency in Industry: *Results from the Texas Pilot Project on Manufacturing Plant Energy Efficiency Certification*.

Ferreira, F.J.T.E. (2009). *Energy Efficient Electric Motors and Drives* [PDF document]. Institute of Systems and Robotics University of Coimbra, Portugal. Retrieved from http://scripts.mit.edu/~mpp-ses/wiki/images/e/ee/ISR-UC-MIT-Presentation-April2009-1.pdf

Gordić, D., Babić, M., Jovičić, N., Šušteršič, V., Končalović, D., & Jelić, D. (2010). Development of energy management system – Case study of Serbian car manufacturer. *Energy Conservation and Management, 51*, 2783-2790.

International Organization for Standardization. (2011a). ISO 50001 Energy management systems – Requirements with guidance for use. Published June 15, 2011.

International Organization for Standardization. (2011b). Early ISO 50001 adopters report major gains through energy management standard. Retrieved from: http://www.iso.org/iso/pressrelease.htm?refid=Ref1448

Kiliccote, S., Piette, M.A., Ghatikar, G., Koch, E., Hennage, D., Hernandez, J.,… Goodin, J. (2009). Proceedings from the Grid-Interop Forum 2009: *Open Automated Demand Response Communications in Demand Response for Wholesale Ancillary Services*. LBNL 2945-E.

King, C., & Delurey, D. (2005). Efficiency and Demand Response: Twins, Siblings, or Cousins? Public Utilities Fortnightly 143(3).

National Action Plan for Energy Efficiency (2010). Coordination of Energy Efficiency and Demand Response. Prepared by Charles Goldman (Lawrence Berkeley National Laboratory), Michael Reid (E Source), Roger Levy, and Alison Silverstein. Retrieved from: http://www.epa.gov/eeactionplan

Piette, M.A., Watson, D., Motegi, N., Kiliccote, S., and Xu, P. (2006). *Automated Critical Peak Pricing Field Tests: Program Description and Results*. LBNL-59351.

U.S. Council of Energy-Efficient Manufacturing. (2012). Achieving Superior Energy Performance – Overview. Retrieved from http://www.superiorenergyperformance.net/

U.S. Green Building Council. (2011). LEED Pilot Credit Library – Pilot Credit 8: Demand Response. Retrieved from http://www.usgbc.org/ShowFile.aspx?DocumentID=7711

Wessels, A. (2011). Proceedings from the 8th Conference on the Industrial and Commercial Use of Energy: *Energy management system implementation at Toyota SA*.