Energy Conservation at the University of Pittsburgh - FY2014 and Beyond

Energy Conservation has long been a priority in Facilities Management. Understanding the large impact of utility costs on the University's budget, FM is investing additional resources and implementing new systems and technologies to place even further emphasis on conservation. A model has been developed to explain the inter-relationship of these tools and resources that must be integrated to realize FM's aggressive goal of reducing energy consumption in existing buildings by 10% or more within the next five years.

The Energy Conservation Process - CMMA

Energy Conservation at the University of Pittsburgh is a comprehensive process. It is much more than turning off lights and installing energy-efficient equipment. What started in the 1970s and 1980s with glorified time clocks and simple control algorithms has evolved to an advanced four-stage conservation cycle that touches many areas of operation. It is a continuous cycle that has no beginning and no end. The stages include Control, Maintenance, Measurement, and Analysis (CMMA), and all four play integral roles in reducing the energy bottom line. This process will lead the University even further in its quest to reduce energy consumption and costs while reducing the University's carbon footprint. Facilities Management (FM) firmly believes that the most sustainable energy is the energy we never use.

CMMA Cycle

Control

FM installed the University's first campus building automation system (BAS) in 1975. Some 37 years and several iterations later, the system has evolved to become a highly sophisticated Energy Management System (EMS). What began with one computer server and several hundred controlled points has grown into a complex information technology network with eight servers and numerous switches/hubs controlling many thousands of controlled, networked, and virtual points. Pitt is rather unique in that our system has been standardized to one major control system. While many universities struggle with integrating various automation systems across their campuses, Pitt was one of the first universities in the nation to capitalize on the many advantages of standardization. This has greatly simplified not only day-to-day operations, but also the process of integrating additional systems with the EMS system. For example, electric and steam metering has been integrated to allow electronic collection and trending of energy consumption and demand data. Chilled water metering is currently being incorporated as well. Very few if any universities have incorporated metering systems with such an extensive scale or scope

with their EMS systems. This capability will provide many distinct advantages moving forward, particularly with the implementation of FM's new Enterprise Energy Management System, described below in the "Analysis" section.

FM estimates that approximately 80% of Pitt's campus building area is now controlled by the EMS, and this percentage is continually increasing as buildings are constructed or renovated. The sophistication of building controls has also evolved significantly over the years. Modern buildings, particularly research buildings, require higher levels of control sophistication than ever before. Over the past few decades, introduction of new technologies into the building control industry has enabled the University to implement new energy management initiatives. For example, Programmable Logic Controllers (PLCs) provide the ability to obtain direct feedback on actual conditions within our buildings and systems and complex control algorithms allow us to control environmental conditions at required performance levels.

A prime example of the level of sophistication now being incorporated into the EMS system is demand controlled ventilation. In the past, most HVAC systems were designed to supply ventilated air based on assumed conditions rather than actual conditions. Since most university facilities are not occupied 24/7/365 days per year, this design technology often results in the continuous over-ventilation of classrooms, laboratories, and offices. By utilizing technologies such as occupancy sensors and time of day schedules, we have been able to design HVAC systems to deliver the required amount of ventilation rather than the assumed quantity needed to condition the space. Since all air entering or circulating through a facility typically needs to be heated or cooled, reducing the need for conditioned air results in significant energy savings.

A new technology is currently being implemented to take demand controlled ventilation to an even higher level. An Aircuity system was recently installed at the Mascaro Center for Sustainable Innovation. The system collects air samples to measure critical elements of the indoor air environment such as carbon dioxide (CO_2), carbon monoxide (CO), dew point temperature, and total volatile organic compounds (TVOCs). The collected data allows the system to control ventilation rates based on actual air quality rather than designed ventilation rates and schedules. The system is designed to meet the critical parameters required for a safe and comfortable working environment while reducing conditioned airflow. Ventilation rates are optimized based on the actual environmental conditions in the space, resulting in significant energy savings. The MCSI installation is currently being commissioned, and even in this early stage, has shown very promising results. Additional installations are planned for the Mid-Campus Research Complex renovations and the additions to the Graduate School of Public Health and Salk Hall. FM also plans to test the installation of Aircuity in animal facilities, which, if successful, could provide even greater savings opportunities.

Maintenance

Building maintenance is integral not only to FM's service mission, but also to campus energy conservation. Proper maintenance of building systems is essential for system reliability and environmental comfort, and is equally essential for system energy efficiency. For example, if air filters

are not changed appropriately, heating and cooling systems may need to work harder to satisfy space conditions. Similarly, if building controls and sensors are inoperable or not properly calibrated, heating and cooling systems might not operate at optimal efficiency.

FM is in the process of upgrading its computerized maintenance management system (CMMS). The previous system produced work orders for equipment and systems based on established maintenance tasks and schedules. These tasks and schedules were developed over the years from manufacturer's recommendations and rules of thumb. The new system will take preventive maintenance to a more sophisticated "predictive maintenance" level.

The new system has the ability to work integrally with the Energy Management System (EMS) to schedule maintenance tasks based on actual need vs. established time schedules. One example of the benefits of the new system is filter replacement. Rather than scheduling replacement of filters on a monthly or semi-annual basis regardless of condition, the new system will have the capability of monitoring the difference in air pressure before and after the filter. In this instance, the CMMS will monitor air pressure sensors via an electronic link to the EMS system (where air pressures are already monitored). When the CMMS system finds that the pressure differential exceeds an established system set point, the CMMS will automatically produce a work order to have the filter changed. This will both decrease the number of filters changed prematurely, and will contribute to energy savings by changing filters before they affect system efficiencies. Intelligent filter changes are only one example of the capabilities of the new system. FM is in the early stages of implementing the system in several pilot buildings, but foresees the potential for significant improvements in system reliability and energy efficiency.

Measurement

FM understands that a critical component to controlling energy consumption is understanding how and where energy is used. To this end, the University has invested extensively in energy metering and monitoring equipment in campus facilities. The campus E-Meter system measures and collects electricity consumption and demand data for Pitt buildings. This system not only benefits FM by identifying building consumption and demand levels, but is also a powerful troubleshooting tool. For example, the meters recently allowed FM to troubleshoot a power quality complaint in the Biotechnology facility. Meter data enabled FM engineers to identify a problem with a failed soft-start motor starter on the building's chiller. This problem was not only contributing to excess energy consumption, but was also causing issues with research and placing unnecessary strain on the chiller. The problem was quickly resolved by replacing the motor starter. The E-meter system has also been an invaluable tool for FM engineers during power outage events. At a glance, engineers can determine which buildings are impacted by outages. This allows personnel to quickly identify the source of the outage and to switch loads as required to protect university assets and research. The E-Meter system data is currently being integrated with FM's new Enterprise Energy Management System (EEM), described in further detail in the "Analysis" section below.

Steam consumption and demand are also metered for all buildings connected to the two central steam plants serving Pitt's campus – the Carrillo Street Steam Plant and the Bellefield Boiler Plant. The two plants are interconnected via the underground steam distribution system. The steam supply is metered upon entry to each building, and sometimes at additional points within buildings. This meter data is used to both identify building consumption and to allocate steam charges among buildings. Since the steam distribution system serves buildings beyond the Pitt campus, the metering system is also used to calculated charges to non-University entities. Steam consumption and demand data is collected in 15 minute intervals, which allows FM to graphically trend consumption by building meter. This trending is very useful in identifying potential problem areas. For example, a recent trend analysis identified unusual spikes in steam consumption which have been linked to operational problems within a building. Like the E-Meter system, the steam metering system has been integrated with the EMS system and is being linked to the new EEM system.

FM is working to expand its chilled water consumption metering to include all buildings served by both the lower campus (Posvar) and upper campus (Petersen) chilled water plants. The meter data is currently being used to allocate the cost of producing chilled water to non Educational and General operating units. The expansion of the metering system will allow FM to allocate chilled water usage to all buildings served by the plants. This will assist FM by providing an additional tool to help determine and compare total building energy efficiencies. The chilled water metering will also be integrated with the EMS and EEM systems.

Natural gas and water meters are typically the responsibility of the utility companies. However, FM analyzes all bills and regularly checks meter readings to ensure accuracy. FM also evaluates consumption regularly to identify areas of concern. FM has installed sewage credit meters in many buildings to achieve credits from the Pittsburgh Water and Sewer Authority (PWSA). Since sewage bills are calculated based upon water consumption, the University has installed these credit meters to identify water usage that does not flow to the sewer. For example, water used in campus cooling towers is evaporated to the atmosphere and never reaches the sewer. Meters installed on the make-up water lines for these towers identify this consumption and the University receives sewage credits for this amount. Similarly, credit meters are installed on campus irrigation systems since this water is absorbed into the soil and does not enter the sewer. Sewage credits for FY2011 eliminated sewage charges for over 61 million gallons of water, resulting in cost savings of $248,000. These credits will be sustained in future years.

Analysis

A major effort is underway in FM to implement a new Enterprise Energy Management (EEM) system. This system will provide a powerful tool to advance FM's energy management process moving forward. The key goals and components of the system include:

- Streamlined management of utility consumption and billing data
- Automated verification of accuracy for utility bills

- Automated collection and import of data from electric, steam, and chilled water meter readings via the EMS system
- Automated weather normalization for energy consumption data for comparison and projection purposes
- Expanded and improved data analysis, utility rate trending, forecasting, and benchmarking capabilities
- Tools for calculating and documenting cumulative savings from completed and potential energy conservation initiatives
- Benchmarking tools to compare energy efficiencies across buildings, identify variations in consumption across time periods, etc.
- Tools to simplify and improve the accuracy of utility budget projections
- Customized reporting tools

The new system will replace an old FASER utility database formerly used to manage utility information. The old system is no longer supported by the vendor and does not have the capabilities required for sophisticated energy management. EEM will greatly simplify the collection, retrieval, and analysis of energy data. This capability is critical to understanding building energy efficiencies, identifying areas for improvement, and projecting energy requirements for the future.

Other Conservation Initiatives

Retro-Commissioning

FM is in the early stages of development for a building retro-commissioning program to help identify areas for energy and operational improvements within existing facilities. When buildings and major renovations are completed, commissioning agents are employed to ensure that building systems are installed in accordance with construction documents, and that the systems are operating within design parameters. For example, building systems are tested to ensure proper control sequences, airflows, space pressurization, and temperature control, among other parameters. Over the years, however, the building's systems can drift from these ideal design conditions due to many factors. These factors may include interior renovations or changes to the use of space within the building, maintenance issues such as inoperable valves, dampers, actuators, or sensors, or changes in building temperature setpoints or other control factors. Retro-commissioning is a process where the building systems and controls are reevaluated and modified to bring them back to optimal design conditions. The process is very similar to that employed during construction and renovation projects.

FM plans to develop a team that will be charged with retro-commissioning University facilities on a periodic basis. The goal is to identify problems and areas for improvement within existing buildings, and to correct those problems to allow the systems to operate as efficiently and effectively as possible. FM has performed similar work in selected areas in the recent past with good results. The current plan is to formalize the process and team structure to allow for evaluation of all buildings on a periodic basis. The program will be designed to evaluate the most energy intensive facilities on a priority basis, and will

utilize all of the existing management tools (EMS, CMMS, EEM) to facilitate the team's work. As part of this effort, FM's operating engineers will undergo additional training to allow them to play a more central role in energy conservation.

An effort is also being planned to retro-commission and optimize the upper campus chilled water plant operation. A project is nearing completion to install free- cooling capabilities at the plant, and this effort will look to expand upon that project to provide greater opportunities for energy savings. This work may be done in conjunction with an effort to obtain PA Act 129 funding. FM is working with consultants from Duquesne Light to identify projects for potential energy rebates related to PA Act 129, which requires electric utility providers to reduce generation by prescribed amounts over a set timeframe.

Demand Response

The University has participated for the past several years in PJM's demand response program. PJM is the regional transmission organization (RTO) that coordinates the movement of wholesale electricity for the geographical region consisting of most of Pennsylvania and portions of twelve other states and the District of Columbia. The demand response program makes arrangements with end-use customers to reduce their use of electricity in response to power grid needs. The customers agree to reduce their electricity use during high use "events". In return, the end users receive monetary compensation. Demand response allows RTO's to balance grid supply and demand. When demand is high, less efficient generators are brought on line to increase the supply, or in more extreme cases, additional generation facilities must be constructed. By reducing demand during these periods, the market can potentially avoid using these less efficient resources or constructing new facilities. The University's participation for FY2010-FY2012 resulted in payments to the University of nearly $92,000. FM signed on to participate again for FY2013 and FY2014.

In response to this program, the University developed a curtailment program to comply with required reductions. This program is automated through the EMS, and resets the temperature control ranges on all of the controlled spaces to higher setpoints (75 degrees instead of 73 degrees) during the peak power usage days. This action reduces the air conditioning load on the chiller plants, thereby reducing electric usage. The curtailment process not only helps the University to save money on the electric bills, but also reduces Pitt's capacity quantities which are used to determine our electric rates going forward. Lower capacity quantities translate to lower electric rates for the next year. This curtailment program began with only a select set of buildings, but has been expanded in recent years to a larger segment of campus buildings.

On a similar note, FM also has the capability to curtail steam consumption in the winter. This capability allows the campus steam load to be reduced during emergency situations when the Bellefield or the Carrillo Street steam plants experience operational issues that reduce their production capacity. Several levels of curtailment are designed into the program to reduce consumption gradually depending on the severity of the situation. All levels of curtailment are designed to give priority to hospitals and research areas.

While all curtailment to date has been in response to emergency situations, FM is investigating the possibility of voluntarily implementing the curtailment programs in ways that would save energy without greatly impacting building comfort levels.

Water Saving Initiatives

FM has incorporated many water-saving initiatives into recent renovation and construction projects with very positive results. For example, low flow plumbing fixtures at the Chevron Science Center addition are designed to use approximately 40% less water than traditional fixtures. Similar fixtures have been installed with the Benedum Hall renovations, and consumption in the building has shown a reduction of approximately 40% to date, with some floors not yet completed. FM is planning to expand this effort to existing facilities by installing low-flow devices on faucets and shower facilities in a phased approach. Additional fixtures will also be evaluated for possible water efficiency retrofits.

Energy Conservation efforts must continue with even greater emphasis in order to meet the University's budgetary challenges and to improve campus sustainability moving forward. Facilities Management believes that investments made in the resources and tools described above will lead the University to creative new opportunities for conservation in the years to come.