Acknowledgements

This report was prepared for the Build Smart NY program at the New York Power Authority to provide options and analysis for the design and implementation of energy efficient O&M practices in New York State government buildings. We would like to extend our gratitude to Gabriel Cowles, Build Smart NY Project Manager; Lloyd Kass, Build Smart NY Project Director; and our Faculty Advisor, Professor Steven Cohen, for their guidance, expertise, and feedback throughout the course of the project.

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Spring 2014 Workshop in Applied Earth Systems Management
The Workshops in Applied Earth Systems Management and in Applied Earth Systems Policy Analysis are among the key components and the core curriculum of the Master of Public Administration in Environmental Science and Policy program at Columbia University. Students in each workshop group work together under the supervision of a faculty member to integrate knowledge and organize an effort to solve an environmental policy problem. In the spring semester, each workshop group completes a project and a report analyzing an actual environmental policy or managerial problem faced by their governmental or nonprofit client.

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## Acronyms

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<th>Description</th>
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<tr>
<td>ASHRAE</td>
<td>American Society of Heating, Refrigeration, and Air-Conditioning Engineers</td>
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<td>BAS</td>
<td>Building Automated System</td>
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<td>CMMS</td>
<td>Computerized Maintenance Management System</td>
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<td>EMS</td>
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<td>EO 88</td>
<td>Executive Order 88</td>
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<td>ESPC</td>
<td>Energy Savings Performance Contracts</td>
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<td>EUI</td>
<td>Energy Use Intensity, often measured in kBtu per gross square foot of building area</td>
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<td>NYPA</td>
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Executive Summary

New York State’s Executive Order 88 mandates 20 percent energy efficiency improvement in State government buildings from 2010 levels by the year 2020. The New York Power Authority has been tasked with managing this State initiative, known as Build Smart New York (Build Smart NY). Improving operations and maintenance (O&M) practices and procedures is a key part of helping State buildings meet these energy improvement targets.

Our research identified four key methods for improving O&M practices in buildings:

1. Changing the behavior of building maintenance staff and occupants;
2. Installing automated building operations systems and software;
3. Analyzing data for cost-savings; and
4. Implementing low to no cost O&M practices.

Our study found that many successful energy efficiency initiatives at the facility level employ at least one of these elements, but in many instances several of these methods were used in combination in order to achieve energy saving results.

Our research into O&M strategies was guided by the data provided by the New York Power Authority (NYPA). Their data indicates that the largest energy consumers among state government facilities included universities, correctional facilities, transit buildings, and office buildings. Our study included a literature review of O&M best practices, over 25 interviews with O&M experts, and analysis of case studies of O&M initiatives. Below is a summary of the main findings of successful O&M initiatives.
Main Findings

1. Staff and occupant engagement in conjunction with changes in operations is vital to improved maintenance and energy savings
   - Staff and occupant engagement and proper building maintenance are key to realizing the full energy savings potential of operations and maintenance efforts.
   - Proper building operations and maintenance, adequate training for maintenance staff, and programs creating energy efficient cultures for building occupants are essential components of operation and maintenance programs.

2. Installing automated systems and software can help facilities achieve energy efficiency improvements while offering quick paybacks
   - Automated building operating systems are a reliable way to control sophisticated systems and help maintain energy savings, as well as allow building managers to track energy consumption.
   - Automated systems allow programming control of operations to streamline building operations.
   - Automated systems collect data and provide a benchmark for which to track and compare energy-saving activities.
   - Automated systems assist in monitoring resource usage, costs, inventory, and any scheduled maintenance work.

3. Analyzing energy data helps building operators react quickly and make cost-saving improvements
   - Energy performance data is essential to identifying building operations performance, effectively planning for energy improvements, and continuously monitoring energy usage in order to enhance efficiency.
   - Data is an effective tool for understanding energy demand and for incentivizing more energy-efficient occupant behavior.
   - Benchmarking and utility bill analysis are two commonly used methods for identifying the current operating performance of buildings.

4. O&M practices can be low-cost measures that lead to significant energy and cost savings
   - Realizing that significant savings can be achieved through minimal investment is important for effectively promoting O&M plans throughout facilities across New York State.
   - The cost of reducing excessive and unnecessary energy consumption can be more than made up for in energy and cost savings through building operations improvements.
   - Energy and cost savings improvements are both data and behavior driven.
Study Background

Introduction to Build Smart NY and Executive Order 88

Build Smart New York (Build Smart NY) is a state initiative aimed at improving energy efficiency in the most energy intensive buildings and campuses owned and operated by New York State. Build Smart NY also promotes green job growth and energy resilience in New York State. Executive Order 88 (EO 88), the key legal authority at the center of Build Smart NY, was issued by New York State Governor Andrew M. Cuomo in December 2012. EO 88 mandates a 20% energy efficiency improvement in NY State government buildings by April 2020. More specifically, this Executive Order mandates a 20% reduction of energy use intensity (EUI) in State-owned and managed buildings, using fiscal year 2010/2011 as the baseline measurement. The Build Smart program targets state buildings greater than 20,000 square feet as they account for more than 90% of the square footage and energy consumption in state buildings, even though they are only 14% of the total number of state government buildings in New York (NYPA, 2013a).

A team at the New York Power Authority (NYPA) has been tasked with coordinating, launching, and managing Build Smart NY. The team is responsible for reporting and benchmarking the following: energy auditing plans, capital project implementation, retro-commissioning, operations and maintenance, and sub-metering. Our research team was tasked by NYPA to focus on the operations and maintenance (O&M) aspect of Build Smart NY.

Introduction to Operations and Maintenance (O&M)

Operations and maintenance refers to the decisions and actions regarding the control and upkeep of equipment and facilities (NYPA, 2013b). Poor O&M practices lead to losses in energy efficiency and its corresponding benefits. In addition to energy and cost savings, O&M practices increase occupant comfort, extend equipment life, and improve building safety. O&M practices that promote energy efficiency include measures taken to properly adjust and maintain equipment and monitor a building’s energy use in areas including lighting, heating, ventilating, and air conditioning.

O&M measures can often be performed by existing facility and maintenance staff. These measures rarely require project design and contracting requirements often needed for time-consuming capital projects. O&M measures also tend to be low or no-cost actions, which can be especially effective when there is little or no room to spare in a tight budget. The O&M measures analyzed in this study include the use of computerized systems, innovative technologies, training, optimization, and incentives encouraging good O&M behavior.

Methodology

After reviewing the literature of energy efficient O&M practices, we compiled a set of case studies and examined them for examples of O&M successes and failures, energy data analysis methods, training and incentive programs, and innovative O&M practices. We also conducted over 25 expert interviews to help assess the lessons learned from the case studies. Our literature review focused on government publications and reports, academic research, and sample O&M plans and reports. Our research identified energy efficient O&M practices being implemented around the world. We searched for examples of building types similar to those owned by New York State’s government. Figure 1 below shows the breakdown of energy use by facility type for New York State. Additionally, interviews with
key experts across the industry were instrumental in learning how O&M considerations, procedures, and practices are incorporated in real-world building operations. Interviews were conducted with energy efficiency engineers, project managers, facility managers, policy advisors, and academic researchers.

Figure 1 Energy use by major New York State government facility types (NYPA, 2013a)

About This Report

This report is organized into four chapters, structured around the main findings of our research:

1. Staff and occupant engagement in conjunction with changes in operations is vital to improved maintenance and energy savings
2. Installing automated systems and software can help facilities achieve energy efficiency improvements and while offering quick paybacks
3. Analyzing energy data helps building operators react quickly and make cost-saving improvements
4. O&M practices can be low-cost measures that lead to significant energy and cost savings

Case study examples are included throughout the body of the report. Full case study write-ups are included in Appendix C.

It is interesting to note that several of the case studies include more than one of our key findings in their successful implementation of O&M practices. For example, Cornell University used sensors that provide constant data to initiate campus-wise behavior changes. In another example, to meet their energy reduction targets, the University of British Columbia implemented a building tune up program to enhance savings potential from maintenance across its campus along with initiatives to engage faculty and staff in energy saving behavior. These examples highlight the importance of taking a multi-faceted approach in O&M project planning processes.
CHAPTER 1

Staff and occupant engagement in conjunction with changes in operations is vital to improved maintenance and energy savings

Staff and occupant engagement and proper building maintenance are key to realizing the full energy savings potential of operations and maintenance efforts. Our research found that proper building operations and maintenance, adequate training for maintenance staff, and programs creating energy efficient cultures for building occupants are essential components of O&M programs.

Building Operations and Maintenance

The operations and maintenance of buildings refers to the practices and work activities employed to keep a facility and its equipment in proper condition. Approaches to maintenance include:

- Reactive: no actions or efforts are taken to maintain equipment.
- Preventive: measures taken to control equipment degradation.
- Predictive: measures taken to detect the onset of system degradation. Maintenance needs are based on the actual condition of the machine/equipment rather than on some preset schedule.

The Department of Energy (DOE) states that most government buildings do not have the necessary resources to maintain equipment in proper working order. Rather, government building operators take a reactive approach to maintenance and wait for equipment failure to occur, and only then take necessary actions to repair or replace broken equipment (Federal Energy Management Program, 2010). When possible, preventive and predictive maintenance should be utilized as part of operations and maintenance practices. Predictive maintenance is often preferred as it places the most emphasis on improving reliability and increasing the longevity of the equipment. A well-defined preventive maintenance strategy can however still lead to substantial energy savings by limiting equipment degradation (NYPA, 2013b).
Commissioning is another important part of assessing building operations and equipment maintenance status. In general, commissioning refers to quality assurance processes such as site walk-throughs, diagnostic testing, and identifying root causes of problems. Several types of commissioning exist (US EPA, 2008), including:

- **Retrocommissioning**: a diagnostic process that identifies how a building’s systems are operated and maintained and considers ways to improve building performance. Retrocommissioning can save money and improve building performance by providing technical detail of the status of each piece of equipment.

- **Recommissioning**: a systematic process that applies to a building’s existing systems and is useful when standardized maintenance and energy management procedures fail to fix chronic building problems. It entails examining and comparing actual building equipment O&M procedures to the intended or designed O&M procedures.

- **Continuous commissioning**: a process that provides real-time monitoring, data analysis, and improved equipment optimization. Continuous commissioning requires advanced energy management systems that provide automated diagnostic actions and allows for programming control setbacks, shutdowns, and startups.

In order to properly assess building operations and equipment status, the appropriate commissioning process should be planned and implemented to include activities such as site assessment, simple repairs, developing lists of deficiencies and repairs, and prioritizing improvements. Commissioning techniques can yield average whole-building energy savings of 16% and simple paybacks of 1.1 years (National Renewable Energy Laboratory, 2013).

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**Building O&M Case Study Highlight: University of British Columbia**

The University of British Columbia’s (UBC) C.K. Choi Building at the Institute of Asian Research has set a precedent for sustainable building design worldwide (New City Institute, n.d.). This groundbreaking, energy efficient building has an energy use of 23% below comparable buildings built in the same years (UBC Campus Sustainability Office, 2009). In 2000 and 2004, the University built the Liu Center for Global Issues and the Life Sciences Center, which is the largest post-secondary research facility in British Columbia. These two buildings are respectively 34% and 30% below ASHRAE standards of energy efficiency (UBC Campus Sustainability Office, 2009).

As part of their energy efficient measures, UBC launched a Building Tune Up program, also known as “Continuous Optimization” in 2010. This is in line with the university’s Climate Action Plan, aimed at reducing GHG emissions by 33% by 2015 based on 2007 baseline levels. From 2010 to 2015, UBC will implement a “tune-up” program on its Vancouver campus. The University piloted the program in two buildings: Buchanan Tower and Neville Scarfe. Within these piloted buildings, a myriad of O&M changes were made from June 2010 to August 2010. The process of monitoring the progress will include monthly and annual progress reports, and in the case of energy over-consumption, the Operations Center will be alerted of the issue to investigate its cause and return the building to its “optimized state.” The Building Tune Up Program will be considered a success after achieving 12% overall energy use reduction in the 72 participating buildings (UBC Sustainability, n.d.).
Building O&M Case Study Highlight: University of British Columbia (continued)

Figure 2 Portfolio energy consumptions are displayed on the Pulse Energy Dashboard (Performance Systems Development Consulting, 2014)

Figure 3 Portfolio Performance Summary overview on the webpage of the University of British Columbia UBC Energy Dashboard (UBC Energy Dashboard, 2014)
Training

Facility equipment performance is directly linked to the capabilities of individuals responsible for a building’s day-to-day operations. Buildings can be poorly operated and maintained, leading to significant energy waste, even in cases where there are automated systems in place to assist with building operations (Underhill, 2014). Training and ongoing education for facility managers, energy managers, building operators, and staff responsible for daily building operations are vital components of effective operations and maintenance procedures.

Proper training increases the likelihood that a facility’s equipment will run effectively and efficiently for the full duration of its expected lifespan. Training also educates operators on how to most effectively analyze and use incoming energy usage data from automated building monitoring systems. With properly trained building operators, it is common to find energy costs reduced between 10%-20%, occupant comfort greatly increased (complaints decrease), and equipment life extended throughout buildings (R. Underhill, personal communication, February 13, 2014).

Effective training programs are fairly intensive, requiring buy-in from all affected stakeholders, particularly employers. Employers must provide both the funding and time for its employees to be trained. Two ways to enhance stakeholder involvement are to include O&M staff in the development of energy management planning processes, and to hire skilled tradesmen as energy related needs are identified. Currently, most training opportunities tend to focus on developing trade skills, but could be enhanced to cover energy-management related issues.

Appendix D lists the top five national certification programs in building operations, illustrating the amount of time necessary for employees to earn initial accreditation as well as continued education units (CEUs) in order to retain certification. Certified employees enhance worker competency and the ability to accomplish O&M related responsibilities (Gazman, Putnam, Wozniak & Lenihan, n.d.).

Case Study Example

The Oregon Department of Administrative Services (ORDAS) focused on two areas, people and technology, in their Sustainability Plan. An integral part of the plan was to ensure building operators were well trained on any new technologies and software in order to realize full energy savings potential in energy reduction efforts (Shepard, 2010).
Training Case Study Highlight: Massachusetts Department of Corrections

The MA Department of Correction serves as an exemplary case study for coupling expensive retrofits, energy performance contracts (EPCs) and renewable energy installations with no-cost occupant engagement to see results with energy conservation. The state was able to leverage funds to install solar and wind capacity on several of their correctional facilities, and has undertaken contracts with energy service companies (ESCOs) for EPCs, recommissioning and retrofits. Additionally, there is a robust staff and occupant engagement effort that stemmed from both the top-down and mid-level management. The state-level commitment to energy reduction provided the spark to critically look at the energy use within the department.

Andy Bakinowski, the project manager for the DOC Division of Resource Management, helped spearhead the various energy efficiency initiatives. First steps included committing to turning off computers and lights overnight and over the weekends. This was aided by computer software that shuts down the machine after twelve hours without use, which saved two million kWh in the first year of use (A. Bakinowski, personal communication, March 9, 2014). Bakinowski said that staff and occupant engagement is the result of periodic trainings, and that most of the staff eventually bought into the policies after realizing that money saved from energy conservation would go towards supporting other programs and ended up in budgets for new equipment (personal communication, February 28, 2014). The DOC also engages staff through a period of voluntary compliance that evolved into required compliance. Certain staff members were assigned to check offices and document which employees left their lights or computer on over the weekend. The superintendent would send reminders and then after several “violations” would publicize the offenders. This strategy of enforcing participation among employees has led to widespread energy conservation practices, and broad engagement with energy from all staff.

Occupant Engagement

Educating and engaging building occupants is a simple, yet often overlooked, step to reducing energy usage. Staff awareness and behavior change campaigns have resulted in significant energy savings in a variety of work settings. Public education and marketing can help create a cultural shift toward more energy conscious occupant behavior.

Incentive programs can be used to promote cooperation from building occupants. Generally, incentives for promoting beneficial occupant engagement come in financial and administrative forms and can be offered at either the staff or facility level (Atlanta Regional Commission, 2012). At the facilities level, financial rewards such as rebates can be given to those facilities that meet or exceed reduction targets and important milestones, such as meeting training goals. Administrative incentives, including recognizing and rewarding building operators and staff, promote incentives for exhibiting regular energy efficient practices.

Case Study Examples

- Hollins University in Roanoke, VA introduced a daily “low power hour,” which requires the University to reduce electric consumption by a predetermined amount on days when the power grid is strained. Hollins observed that the behavior change continued long past the indicated hour, and this program helped them reach their overall goal of a 9% energy reduction target (Hollin News, 2012).
Staff and Occupant Engagement Case Study Highlights:
Provincial Health Services Authority, Fraser Health Authority, Providence Health Care, Vancouver Coastal Health Authority

British Columbia’s health centers are aware of the important role that employees play in the energy efficiency of a building since they are the ones that occupy these spaces, and hence have the potential to affect energy consumption levels in significant ways. These organizations have implemented staff and occupant engagement programs to promote sustainable behavior in order to complement the energy efficiency features and technologies installed in buildings. One of these programs is Green+Leaders, an environmental education and behavior change program created to foster the sustainability culture. The program also helps to identify areas of opportunity for change. Green+Leaders works on a volunteer basis to involve staff that are already interested in sustainability practices. This not only helps to retain the people engaged in the program and build organizational capacity, but also mitigates corporate risks (O. Dempsey, personal communication, March 3, 2014). Another lesson learned was the importance of working with a small group of managers (since 2009 over 260 managers have been trained).

In particular, the energy reduction campaign within the Green+Leaders program focuses on four main tools: computer power settings, energy audits, “turn it off” and print device best practices. Successful actions that can modify habits and create behavior awareness are: sharing responsibility with other colleagues, reminding through one-on-one conversations, incorporating reminders, monitoring the number of lights and monitors that are left on and off, and the use of stickers to promote the desired behavior. Alternative projects include designating a team member to ensure that heaters, chargers and other non-essential equipment are powered off before leaving the workplace. On the other hand, one of the main weaknesses about the program is the variability of results among different workplaces, which can be attributed to pre-existing awareness, staff cohesion, workload, as well as leadership and approaches used by managers. Other challenges include the loss of effectiveness of stickers once staff becomes accustomed to them and the use of portable heaters and air conditioning devices because of changes in building temperature (Dempsey, 2013).

It is important to be aware that permanent behavior changes take time, and motivation and inspiration is needed to sustain a volunteer staff and occupant engagement program. This is why evaluation of the program and volunteer training should be held on a constant basis. Each year the Green+Leaders program holds training in the fall, and a recognition event and program evaluation during the spring. They also promote motivation and inspiration through information sharing between working groups, educational events, and networking (O. Dempsey, personal communication, March 3, 2014).

Case Study Examples (continued)

- Cornell University in Ithaca, NY estimates that if laboratory fume hoods were hibernated during weekends and school breaks, they would save 40% of annual operating costs. Even when a fume hood is in use, closing the sash at all times has the potential to save roughly 60% of the energy consumed (Cornell University Sustainable Campus, n.d.).

- The University of British Columbia in Canada engages students and employees by releasing energy use information in buildings across their campus. In addition to data, the University includes detailed but easily understood information such as “What does this mean for me,” “What kind of changes will happen in my building,” and “What can I personally do to save energy” (UBC Sustainability, n.d.).
A Dutch consulting firm conducted an experiment with 83 employees across 5 departments in order to identify and measure the energy behavior of building tenants. Social and financial rewards were distributed based on weekly energy consumption.

Two departments received social rewards, two departments received monetary awards, and one department received no incentives as a control. Employees received “Personal Energy Saving Reports” detailing their individual energy consumption, the percentage they had conserved compared to their baseline, and their reward. Monetary rewards ranged from $0-$7 and social rewards were grades from 5.0 to 10.0 followed by a descriptive comment (e.g. “unfortunate” to “great”). One department in each reward system also received a table containing the same information for their colleagues (Handgraaf et al., 2013). The graph below shows how social rewards had the greatest impact on energy efficiency within the studied firm:

Figure 4 Percentages of energy saved in each of the conditions (including control) over the entire period (the 11 weeks following baseline measurement). Rewards were given during the shaded weeks (weeks 1, 2, and 3) (Handgraaf et al., 2013).
CHAPTER 2
Installing automated systems and software can help facilities achieve energy efficiency improvements while offering quick paybacks

Automated building operating systems are a reliable way to control sophisticated systems and help maintain energy savings, as well as allow building managers to track energy consumption. For example, an Energy Management System (EMS) or a Building Automation System (BAS), is comprised of systems that provide automated diagnostic actions and allow programming control setbacks, shutdowns, and startups among other energy-reducing actions. Additionally, an EMS collects data and provides a benchmark to track and compare energy-saving activities (National Renewable Energy Laboratory, 2013).

Software such as a Computer Maintenance Management System (CMMS) assists in monitoring resource usage of specific systems, such as buildings and vehicles, as well as their costs, inventory, and any scheduled maintenance work (BOMA International, 2013). For example, if an office building needs electrical repairs, automated CMMS systems can help agencies identify and schedule necessary repairs. A list of the types of CMMS systems is included in Appendix E.

IN FOCUS
The Modern Outlet
Vampire loads are the power used by devices when they are not in operation, sleeping, or on standby, and account for a major energy loss in homes and buildings. The Modlet (a ThinkEco product) is an intelligent outlet that can be set for individual devices to be turned on and off at scheduled times throughout the day. The Modlet also comes with software that provides data and feedback that manages energy through automated savings and behavior change (ThinkEco, 2014).
Case Study Examples

• Northeastern University in Boston, MA found building automation plays a significant role in their energy usage. They have optimized their system with a series of algorithms that adjust to lower consumption during peak demand and provide feedback on system failures (Powers-Lee, Ranahan, Rosskam, & Ziola, 2010).

• Cornell University installed sensors across their campus that allow for constant monitoring of data throughout 50 buildings on campus (Friedlander, 2013). This data is available as a live dashboard online for all parties to access, watch, and compare. Energy usage is shown in units of energy and cost. This data can be compared to monthly averages, and social media contests are used to encourage students to visit and interact with the site (Friedlander, 2013).

• The Changi Prison Complex in Singapore implemented Metrolight’s 250W SmartHID and Menolix automated lighting control and central monitoring system, which led to improvements in energy efficiency, reduction in maintenance costs, and enhanced control of lighting dimming capabilities. The use of this automated technology resulted in 44% energy savings and 50% reduction in maintenance costs (Metrolight, 2009).

• The Z3 office building in Stuttgart, Germany deployed automated Kieback&Peter technology such as “LonWorks,” which enables the integration of various energy systems into a single network. For example, blind and lighting control in Z3 is integrated within the room automation system. Additionally, the building uses room control devices which wirelessly integrate temperature sensors with individual room controllers. This system also allows employees to view the actual status of energy usage in the building and their individual offices right on their computers via a web user interface (Kieback&Peter, 2014a).

IN FOCUS
Night Watchman Technology Saves Hospital $40,000 Annually

Gundersen Health System in La Croix Wisconsin uses more than 8,500 computers. Many of these computers were left on 24 hours a day, seven days a week, a practice that led to a large draw on energy and higher energy costs. Through the Health System’s Envision program, an initiative designed to lower costs via innovative “green” projects, Gundersen implemented their solution. The project included the installation of NightWatchman software on all of the Health System’s computers. The software allows computers that have been left powered on to be automatically turned off at a set time each night (unless they are currently being used). In some cases, using another software offered by the same company, computers are set to turn back on at a specific time in the morning. Gundersen began installing the software within their many buildings in 2009, and completed the installation throughout their system in 2010. Energy savings have reached approximately 645,000 kilowatt hours a year, with an energy cost reduction of $40,000 annually (Envision Gundersen Lutheran, 2014).
Automated Systems Case Study Highlight: Cornell University

Cornell University is a public/private university located in upstate New York. At 14 million square feet, it is one of the largest research universities in the country (Cole, 2005). In 2001, Cornell signed onto the Kyoto compliance goal for college campuses to decrease their greenhouse gas emissions, and in 2009 pledged to be climate neutral by 2050. A large part of their focus has come from initiatives to increase energy efficiency through behavior and operations. One of the most important features of Cornell’s initiative was the installation of sensors that allow for the constant monitoring of data throughout 50 buildings on campus (Friedlander, 2013). This data is available as a live dashboard online for all students, faculty, administration, and other interested parties to access, watch, and compare. This data can be compared to monthly averages and social media contests are used to encourage students to visit and interact with the site (Friedlander, 2013). This feature is particularly useful for competitions such as the “Think Big, Live Green,” competition between 10 engineering buildings. The 2013 competition saved 191,006 kilowatt-hours of electricity and is estimated to have saved the university $16,000 (Cornell University building dashboard, 2014). A separate week-long competition, Campus Conservation Nationals, saved 7,591 kilowatt-hours or more than $1,000 in a week through just behavioral changes (Ramanujan, 2012). This is an effective way to increase student awareness of operational behavior. The behavior change initiatives have not only been directed at students. A recent campaign incentivizes faculty to reduce their energy consumption by adding the saved utility funds to department budgets (Ramanujan, 2012). Other successful efforts have been less about behavior, and more about management. A recent thermostat set-back for nine days over a school break saved $140,000 by setting the temperature to 64 °F and unplugging electrical devices (Friedlander, 2014). Additionally, a recent campaign incentivized faculty to reduce their energy consumption by adding the saved utility funds to department budgets (Ramanujan, 2012).

![Figure 5 Example of the energy dashboard with live energy usage data available online for each building (Cornell University Sustainable Campus, n.d.)](image-url)
CHAPTER 3
Analyzing energy data helps building operators react quickly and make cost-saving improvements

Energy performance data is essential to identifying building operations performance, effectively planning for energy improvements, and continuously monitoring energy usage in order to enhance efficiency. Data management software is an essential tool for building managers to understand energy consumption and demand, and allow managers to run buildings efficiently. Data is also an effective tool for incentivizing more energy-conscious occupant behavior.

Data for benchmarking and utility bill analysis are important for identifying the current operating performance of buildings. ENERGY STAR Portfolio Manager, a system devised and run by the EPA, is used as a common benchmarking strategy. Utility bill analysis provides facility managers and O&M staff with the building’s energy use data and patterns. Utility bill analysis can also provide a monthly and year-to-year analysis of energy use (California Commissioning Collaborative, 2011).

Case Study Example

- As part of the University of British Columbia’s Building Tune Up Program, separate targets for each participating building’s energy consumption were set, and building performance was monitored using real-time energy management software provided by Pulse Energy (UBC Sustainability, n.d.). The process of monitoring the progress includes monthly and annual progress reports, and in the case of energy over-consumption, the Operations Center is alerted to the issue, investigates its cause, and returns the building to its “optimized state.”
Energy Data Case Study Highlight:
Oregon Department of Administrative Services (ORDAS)

ORDAS’s portfolio of 44 buildings of various types—including offices, warehouses, a library, and a data center—surpassed their energy reduction mandates (20% of 2000 levels) in 2010—five years before their 2015 deadline mandated by the Oregon Sustainability Act adopted in 2001 (Shepard, 2010). As an integral part of the agency’s larger Sustainability Plan, tracking and managing building performance focuses on two aspects: people and technology. Without proactive staff and occupant engagement and management, the tools and technology installation alone would not make the success.

Other than utility managers responsible for energy benchmarking and utility bill analysis to track progress toward energy savings goals, ORDAS also relies on Northwrite Inc.’s Energy Expert. The award-winning advanced energy information system is capable of modeling and predicting energy consumption in buildings (Northwrite, 2014). Through Energy Expert, ORDAS continuously collects and analyzes energy use data for the entire building. Their operators are alerted of unexpected demand peaks, and the automation system and data loggers are used to identify system performance issues and excessive energy use.

IN FOCUS
EPA EnergyStar Portfolio Manager

The ENERGY STAR Portfolio Manager, created by the Environmental Protection Agency (EPA) to promote environmental benefits and financial value through energy efficiency, is a free online tool to help facility managers measure and track energy and water consumption and greenhouse gas emissions of their buildings. To utilize this tool, users need energy consumption data, cost information, and operational details. Portfolio Manager is then able to provide up to 100 different metrics and compare the particular building’s performance to similar buildings nationwide through the use of a 1 - 100 ENERGY STAR score. The ENERGY STAR score is based on the Commercial Building Energy Consumption Survey (CBECS), giving the user a ranking compared to the national average. For example, a score of 50 represents median energy performance. Any score of 75 or higher indicates that the facility may be eligible for ENERGY STAR certification (ENERGY STAR, 2014).
CHAPTER 4
O&M practices can be low-cost measures that lead to significant energy and cost savings

Effective O&M measures require little to no cost and therefore can be easily implemented. Unlike other improvements, O&M does not require capital investments or expensive trainings. Many of the cases we reviewed demonstrated that significant energy and money savings were achieved through simple adjustments and behavior modifications. Understanding that significant savings can be achieved through minimal investment is a key realization in effectively promoting O&M plans throughout facilities across New York State.

Checklists are effective and no-cost tools to use when planning and performing successful O&M practices. They have the ability to motivate facility, staff, and tenants through clear, short, and concise goals. Whether these goals are scheduled for ongoing daily maintenance or over a long-term period of time, checklists help yield ongoing energy savings for buildings while promoting occupant health and comfort. See Appendix A for more detail on effective use of checklists and Appendix B for a specific example of a checklist.

Case Study Examples

- Cornell participated in a week-long challenge program known as Campus Conservation Nationals. Over the course of the week, Cornell saved 7,591 kilowatt-hours and more than $1,000 through just behavioral changes (Ramanujan, 2012).

- A thermostat set-back over nine days at Cornell saved $140,000 by setting the temperature to 64°F (Friedlander, 2014).

- The Rush Oak Park Hospital saved more than $340,000 in the first nine months of implementing an energy efficient program targeted at staff education campaigns and reducing visitor space lighting during non-visiting hours (US DOE, 2011).
Low Cost O&M Practices Case Study Highlight:
Mississippi Department of Environmental Quality (MDEQ)

The energy reduction efforts of MDEQ were spearheaded by an energy management team comprised of existing employees. Without any significant expenditure, operational adjustments to the buildings’ unoccupied periods and actual lighting needs, as well as ongoing employee energy awareness campaigns and periodic audits, resulted in immediate savings. MDEQ saw their energy consumption reduced by 37%, saving them over $140,000 per year in operating cost for energy.

Even the most efficient lighting and air conditioning methods have to consider the preferences and habits of the building occupants to enhance cooperation and participation. Setting the most efficient lighting level and regulated temperature can result in employees resorting to additional personal lamps, fans, or heaters, defeating the very purpose of energy saving. To seek further energy use reduction opportunities, the MDEQ continues to monitor and analyze its time-of-day data from the building meters and energy management systems (Mississippi Development Authority, 2011).

IN FOCUS
Occupant Engagement for Energy Efficiency

Building occupants have an important role in the amount of energy that is used. In the specific case of office buildings and universities, lighting represents about 30-45% of the total building electricity use, while equipment plugged into outlets represents about 10-30%. Thereby, actions focused on lighting and office equipment are a good opportunity to reduce energy use (University of British Columbia Sustainability, n.d.).

The actions below, when performed by occupants of the building, can increase energy efficiency with zero cost:

- Turn off the lights when leaving a room
- Turn off some of the lights in the office if they are not needed
- Use a power bar to plug in all office equipment like computers, monitors, printers and peripherals. This will facilitate turning off all equipment at the end of the day
- Set computer power-saving option to turn off the monitor and computer when they are not in use instead of using screen savers
- Actions during summer to keep the rooms cool and reduce the need for air conditioning:
  - Turn off the lights when feasible
  - Close blinds and curtains to prevent heating through sunshine
- Actions during winter to increase heat retention and reduce the need for heating:
  - Open blinds and curtains during the day to heat the rooms with sunlight
  - Close blinds, curtains and windows at night to retain the heat
Simple operations and maintenance practices can lead to significant improvements in energy efficiency and substantial cost savings. We realize that the buildings that fall under the Build Smart NY portfolio might be in various stages of meeting their operations and maintenance goals, but there are several underlying trends that can be applied to all facility types.

Proper building maintenance and staff and occupant engagement lead building managers to realize the full energy savings potential of operations and maintenance performance. Preventive and predictive maintenance and commissioning efforts result in proper building operations and energy savings. Training and ongoing education for facility managers, energy managers, building operators, and staff responsible for daily building operations are vital components of effective operations and maintenance procedures, and result in efficient building operation. Training and education increase staff knowledge, engagement, and behavioral changes, which we have found to be critical to successful O&M improvements. Several case studies reported cultural change after successfully implementing periodic training, incentives, and performance checks. Cultural change takes time and can be more successful by involving staff members who are interested in energy conservation.

Automated building operating systems provide a convenient means of operating complicated building systems and tracking energy consumption. Automated setbacks, shutdowns, and startups help cut back on energy use while simplifying building operations. The data collected by these systems is used to track and compare energy use trends. Facilities managers then periodically evaluate operational performance to determine potential energy-saving opportunities.

CONCLUSION
Energy performance data made available to building managers leads to enhanced efficiency. Benchmarking and utility bill analysis are two common means of identifying operating efficiency of buildings. Analyzing data includes identifying building operations performance issues, planning energy improvements, and monitoring energy usage. Collection and analysis of data helps building managers understand energy demand and drives decision-making processes. Using data more effectively to drive decision-making results in building efficiency improvements and managerial tools for incentivizing more energy-conscious occupant behavior.

Finally, O&M measures can require little to no cost and can be easily implemented. Many low-cost adjustments to building operations and attention paid to staff behavior can in aggregate lead to substantial savings. Realizing these opportunities is the first step for building managers to improve building efficiency, and is a key strategy in effectively promoting O&M improvement plans throughout facilities across New York State.
Appendix A

Effective Use of a Checklist

Efficient operations and maintenance practices ensure building systems function to their most efficient and effective performance levels. To achieve effective operations and maintenance, it is important to ensure planned systems and strategies are carefully outlined in accordance with the resources available to the facility (Department of Design and Construction, 1999).

Staff and Tenant Maintenance Strategies

Reducing waste, conserving energy, and ensuring proper use of installed energy efficient systems during day-to-day building activities are critical for operating at a facility’s highest performance level. Facility managers are responsible for operating and maintaining building systems at the level of designed efficiency according to equipment life expectancy. Traditionally, these systems are not properly maintained for their expected lifecycle because facility managers have higher, more flexible, capital budgets to buy new equipment, and only small operating budgets to properly maintain the systems. Thus, in many cases, there are more incentives to let the systems deteriorate and burn out every 5 years rather than properly maintaining the equipment for its guaranteed 10 years (R. Underhill, personal communication, Feb 13, 2014). Providing the incentives to hold facility staff accountable for the building equipment is a key measure for energy efficient O&M.

Involvement from facility occupants such as tenants in an office building or college students in a dormitory or laboratory has an important role in promoting an energy efficient culture within a facility. Checklists can be effective tools to motivate tenant involvement in day-to-day energy efficiency management.

Developing an Operational Checklist

The steps below, when included in the goal timeline of a facility operating plan as a checklist, lead to energy efficiency:

1. Create a system-wide schedule to support constant commissioning and ensure the building is operating at the highest possible efficiency.

2. Develop and use tracking systems to schedule and record the completion of maintenance activities. For large facilities, for example, a CMMS provides the most effective approach (AECOM Technology Corp., 2009).

3. Design a schedule for building sub metering, and include technology that permits tracking of peak versus non-peak consumption. This allows planning for scheduling of energy intensive systems at off-peak times to reduce demand consumption.

4. Prepare a staffing schedule that builds up the staff of the administrative and management functions of the agency.
Appendix A
Effective Use of a Checklist (continued)

Integrating a Checklist Into Building Operations

Providing the incentives to hold facility staff accountable for the building equipment is a key measure for energy efficient O&M.

- **Step 1:** Commit to a simple checklist for facility management and staff. Ten steps are an appropriate amount as it is short and will not interfere with daily tasks.
- **Step 2:** Train the staff to complete routine checklists detailing the maintenance of systems and equipment.
- **Step 3:** Require that staff email the completed checklists every month to the Energy Manager, reprimanded with strongly worded emails if this is not completed. Any staff members not completing the checklists properly will either get retrained or, if it is a recurring issue, fired.
- **Step 4:** Task the Energy Manager with analyzing these checklists for trends and any alarming data logged.
- **Step 5:** Ensure each staff member has submitted their entry. If the checklists are not completed effectively or not completed at all, the Energy Manager must step in and address the issue. It may be an issue of retraining or re-staffing. Either way the issue must be addressed immediately to avoid additional slack from the employee or additional employees.
Checklists can be effective tools for addressing day-to-day operations of equipment and for establishing higher level or longer term goals. Below is an example of a routine checklist (M. Brown, personal communication, Feb 2014).

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Appendix C
Case Studies

Cornell University

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<tr>
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Cornell University is a public/private university located in upstate New York. At 14 million square feet, it is one of the largest private research universities in the country (Cole, 2005). In 2001, Cornell signed onto the Kyoto compliance goal for college campuses to decrease their greenhouse gas emissions, and in 2009 pledged to be climate neutral by 2050. A large part of their focus has come from initiatives to increase energy efficiency through behavior and operations. One of the most important features of Cornell’s initiative was the installation of sensors that allow for the constant monitoring of data throughout 50 buildings on campus (Friedlander, 2013). This data is available as a live dashboard online for all students, faculty, administration, and other interested parties to access, watch, and compare. This data can be compared to monthly averages and social media contests are used to encourage students to visit and interact with the site (Friedlander, 2013). This feature is particularly useful for competitions such as the “Think Big, Live Green,” competition between 10 engineering buildings. The 2013 competition saved 191,006 kilowatt-hours of electricity and is estimated to have saved the university $16,000 (Cornell university building dashboard, 2014). A separate week long competition, Campus Conservation Nationals, saved 7,591 kilowatt-hours or more than $1,000 in a week through just behavioral changes (Ramanujan, 2012). This is an effective way to increase student awareness of operational behavior. The behavior change initiatives have not only been directed at students. A recent campaign incentivizes faculty to reduce their energy consumption by adding the saved utility funds to department budgets. Other successful efforts have been less about behavior, and more about management. A recent thermostat set-back over nine days saved $140,000 by setting the temperature to 64 °F and unplugging electrical devices (Friedlander, 2014). Additionally, a recent campaign incentivized faculty to reduce their energy consumption by adding the saved utility funds to department budgets.

Laboratories are one of the most energy intensive users within research and university facilities. Cornell identified energy efficient and safe labs as a specific initiative in their efforts to reduce energy consumption. For example, a high consumer of energy is the airflow systems that are required for health and safety. Cornell is currently working to minimize this cost, while conducting research on the health and safety impacts to further understand safe lab spaces. Estimates on the savings potential are roughly $1 per square foot of lab space per year, which is an upwards of $2 million dollars annually for Cornell (Cornell University Sustainable Campus, n.d.). The university has also focused on minimizing the superfluous use of fume hoods in labs and facilities, which account for significant carbon dioxide emissions. If fume hoods were to be hibernated during weekends and school breaks, the estimated savings are 40% of annual operating costs. Even when fume hoods are in use, closing the sash at all times has the potential to save roughly 60% of the energy consumed (Cornell University Sustainable Campus, n.d.).
# Appendix C  
## Case Studies

<table>
<thead>
<tr>
<th>Key O&amp;M Takeaways</th>
<th>Cornell University (continued)</th>
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<td><strong>“Think Big, Live Green” competition between 10 engineering buildings:</strong></td>
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<td>• Saved 191,006 kWh of electricity</td>
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<td>• Saved $16,000</td>
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<tr>
<td><strong>“Campus Conservation Nationals” week-long competition:</strong></td>
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<tr>
<td>• Saved 7,591 kWh</td>
<td></td>
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<tr>
<td>• Saved more than $1,000 through behavioral changes</td>
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<td><strong>Thermostat set-back:</strong></td>
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<td>• Saved $140,000 by setting the temperature to 64°F</td>
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<td><strong>Laboratories:</strong></td>
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<tr>
<td>• Hibernating fume hoods during weekends and school breaks</td>
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<tr>
<td>• Estimated savings of 40% of annual operating costs</td>
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</tr>
<tr>
<td>• Unplugging equipment when not in use</td>
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# Appendix C

## Case Studies

### University of British Columbia

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<tr>
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**Background**

The University of British Columbia’s (UBC) C.K. Choi Building at the Institute of Asian Research has set a precedent for sustainable building design worldwide (“The C.K. Choi Building”). This groundbreaking, energy efficient building has an energy use of 23% below comparable buildings built in the same years (“UBC Case Study: Green Building”). In 2000 and 2004, the University built the Liu Center for Global Issues and the Life Sciences Center, which is the largest post-secondary research facility in British Columbia. These two buildings are respectively 34% and 30% below ASHRAE standards of energy efficiency (UBC Campus Sustainability Office, 2009).

As part of their energy efficient measures, UBC launched a Building Tune Up program, also known as “Continuous Optimization” in 2010. This is in line with the university’s Climate Action Plan, aimed at reducing GHG emissions by 33% by 2015 (based on 2007 levels) (UBC Sustainability, n.d.). From 2010 to 2015, UBC will implement a “tune-up” program on its Vancouver campus. The University piloted the program in two buildings: Buchanan Tower and Neville Scarfe. Within these piloted buildings, a myriad of O&M changes were made from June 2010 to August 2010. The process of monitoring the progress will include monthly and annual progress reports, and in the case of energy over-consumption, the Operations Center will be alerted of the issue to investigate its cause and return the building to its “optimized state.” The Building Tune Up Program will be considered a success after achieving 12% overall energy use reduction in the 72 participating buildings (UBC Sustainability, n.d.).

### Key O&M Takeaways

- Building Tune Up program, or “Continuous Optimization”
- Modifying 72 core academic buildings
- Sustain optimized state through real-time performance monitoring, targeting and reporting
- Demand-controlled ventilation, weather predictors, night and daytime heating controls, and room temperature optimization
- Building performance monitored using real-time energy management software provided by Pulse Energy
Appendix C
Case Studies

<table>
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<th>Facility Type</th>
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<td>Location</td>
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British Columbia’s health centers are aware of the important role that employees play in the energy efficiency of a building since they are the ones that occupy these spaces, and hence have the potential to affect energy consumption levels in significant ways. These organizations have implemented staff and occupant engagement programs to promote sustainable behavior in order to complement the energy efficiency features and technologies installed in buildings. One of these programs is Green+Leaders, an environmental education and behavior change program created to foster the sustainability culture. The program also helps to identify areas of opportunity for change. Green+Leaders works on a volunteer basis to involve staff that is already interested in sustainability practices. This not only helps to retain the people engaged in the program and build organizational capacity, but also to mitigate corporate risks (O. Dempsey, personal communication, March 3, 2014). Another lesson learned was the importance of working with a small group of managers (since 2009 over 260 managers have been trained).

In particular, the energy reduction campaign within the Green+Leaders program focuses on four main tools: computer power settings, energy audits, turn it off and print device best practice. Successful actions that can modify habits and create behavior awareness are: sharing responsibility with other colleagues, reminding through one-on-one conversations, incorporating reminders, monitoring the number of lights and monitors that are left on and off, and the use of stickers to promote the desired behavior. Alternative projects include designating a team member to ensure that heaters, chargers and other non-essential equipment is powered off before leaving the workplace. On the other hand, one of the main weaknesses about the program is the variability of results among different workplaces, which can be attributed to pre-existing awareness, staff cohesion, workload, as well as leadership and approaches used by managers. Other challenges include the loss of effectiveness of stickers once staff becomes accustomed to them and the use of portable heaters and air conditioning devices because of changes in building temperature (Dempsey, 2013).

It is important to be aware that permanent behavior changes take time, and motivation and inspiration is needed to sustain a volunteer staff and occupant engagement program. This is why evaluation of the program and volunteer training should be held on a constant basis. Each year the Green+Leaders program holds training in the fall, and a recognition event and program evaluation during the spring. They also promote motivation and inspiration through information sharing between working groups, educational events, and networking (O. Dempsey, personal communication, March 3, 2014).

Additionally, the Energy and Environmental Sustainability (EES) Green Playbook provides sustainability principles and guidelines for these health centers. It recommends consideration and adoption of best practices standards in existing buildings, new constructions and renovations, behavior change, systemic changes and innovation. From these five focus areas, the ones related to operation and maintenance include existing buildings and behavior change. An example of the results achieved by implementing this program can be found in the British Columbia Cancer Research Center. The estimated annual savings for the 21,000 square meters of research labs and office buildings are 884,000 kWh, and $139,000 Canadian dollars through measures such as reduction of excess ventilation, supply air temperature reset, night temperature setback, and optimization of heating water supply temperature (Hutton, 2013).
## Appendix C

### Case Studies

**Provincial Health Services Authority, Fraser Health Authority, Providence Health Care, Vancouver Coastal Health Authority (continued)**

| Key O&M Takeaways | • Environmental education and behavior change  
|                   | • Involve staff in sustainability practices  
|                   | • Focus on computer power settings, energy audits, turn it off, and print device best practices  
|                   | • Behavior awareness  
|                   | • Sharing responsibility with other colleagues, reminders through one-on-one conversations  
|                   | • Monitor the number of lights left on  
|                   | • Use of stickers to promote the desired behavior  
|                   | • Sustain staff and occupant engagement with annual training, recognition events, and information sharing  
|                   | • Continuous optimization program  
|                   | • Ongoing monitoring and fine-tuning of a building to maintain and improve energy efficiency and reduce operating costs  
|                   | • Reduction of excess ventilation, supply air temperature reset, night temperature setback, and optimization of heating water supply temperature (Hutton, 2013). |
## Gundersen Lutheran Health Center

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### Background

Amidst rapidly rising energy costs of up to an additional $350,000 per year, leading to increased costs for patients, Gundersen Lutheran decided to take a closer look at where costs could be cut in their facility operations. In less than two years, they improved their energy efficiency by 25% and saved over $1 million annually (Envision Gundersen Lutheran, 2014). One of the first and most influential changes they made was switching from three boilers to two boilers that were already operating to sterilize equipment. Using these existing boilers for steam-heating saved an estimated $64,000 annually (Klein, 2009).

Gundersen saw additional savings from a number of other measures, including installing an automated computer system software. The hospital utilizes more than 8,500 computers. Many of these computers were left on 24 hours a day, seven days a week, a practice that led to a large draw on energy and higher energy costs. Through the Health System’s Envision program, an initiative designed to lower costs via innovative “green” projects, Gundersen implemented a solution that has saved the organization approximately $40,000 a year in energy costs. The project included the installation of NightWatchman software on all of the Health System’s computers. The software allows computers that have been left powered on to be automatically turned off at a set time each night (unless they are being currently used). In some cases, using another software offered by the same company, computers are set to turn back on at a specific time in the morning. Gundersen began installing the software within their many buildings in 2009, and completed the installation throughout their system in 2010. Energy savings have reached approximately 645,000 kilowatt hours a year, with an energy cost reduction of $40,000 annually (Envision Gundersen Lutheran, 2014).

### Key O&M Takeaways
- Night Watchman software
- Automated computer shut-down and power-up
- Saved $40,000 per year in energy costs
# Appendix C
## Case Studies

### Massachusetts Department of Corrections

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**Background**

The MA Department of Correction serves as an exemplary case study for coupling expensive retrofits, energy performance contracts (EPCs) and renewable energy installations with no-cost occupant engagement to see results with energy conservation. The state was able to leverage funds to install solar and wind capacity on several of their correctional facilities, and has undertaken contracts with energy service companies (ESCOs) for EPCs, recommissioning and retrofits. Additionally, there is a robust staff and occupant engagement effort that stemmed from both the top-down and mid-level management. The state-level commitment to energy reduction provided the spark to critically look at the energy use within the department.

Andy Bakinowski, the project manager for the DOC Division of Resource Management, helped spearhead the various energy efficiency initiatives. First steps included committing to turning off computers and lights overnight and over the weekends. This was aided by computer software that shuts down the machine after twelve hours without use, which saved two million kWh in the first year of use (A. Bakinowski, personal communication, March 9, 2014). Bakinowski said that staff and occupant engagement is the result of periodic trainings, and that most of the staff eventually bought into the policies after realizing that money saved from energy conservation would go towards supporting other programs and ended up in budgets for new equipment (personal communication, February 28, 2014). The DOC also engages staff through a period of voluntary compliance that evolved into required compliance. Certain staff members were assigned to check offices and document which employees left their lights or computer on over the weekend. The superintendent would send reminders and then after several “violations” would publicize the offenders. This strategy of enforcing participation among employees has led to widespread energy conservation practices, and broad engagement with energy from all staff.

### Key O&M Takeaways

- Periodic trainings for staff buy-in of energy saving behavior (switching off computers and lights overnight and on weekends)
- Computer software that shuts down the machine after 12 hours without use (saved 2 million kWh in the first year)
- Learned how money saved from energy conservation would go towards supporting other programs
- Enforcing participation amongst employees
### Changi Prison Complex (CPC)

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<tr>
<td>Background</td>
<td>The redevelopment of CPC began in 2000, which took into account environmental and operational concerns to maximize cost savings and operational flexibility. The purpose of the redevelopment was to consolidate correctional facilities throughout Singapore into a single location, ultimately accommodating up to 23,000 prisoners. The plan included the creation of four different clusters of institutions, support facilities, and a headquarters in order to localize and separate the the affected areas during redevelopment (CPG Consultants, 2012). The new main lighting requirements for buildings, fences, and streets included reduced maintenance, enhanced lighting control, and energy saving capabilities. The new main lighting requirements for buildings, fences, and streets included reduced maintenance, enhanced lighting control, and energy saving capabilities. They implemented Metrolight’s 250W SmartHID electronic ballast, as well as Menolinx's lighting control and central monitoring system, known as LEMS (lighting energy management software). The redevelopment required three main goals: energy efficiency, reduced maintenance costs, and full control and dimming capabilities. Primarily, the prison increased their control over lighting and overall efficiency by implementing LEMS, which allows them to easily monitor the dimming level and status of each lamp. They also reduced costs by grouping, or by defining groups of lamps for a common mode of operation and settings. They installed automatic lighting controls with cameras, photocells, sensors, and motion detectors. They implemented a two-way communication system, which automatically sends commands and receives ballast parameters and lamp information, contributing to reduced maintenance costs. The communication system also provides end-of-life alerts, such as lamp failures and energy consumption. Finally, CPC now uses automatic equipment scheduling. They also have specific staff divisions dedicated to Operations and Strategic Planning and Research. Through the implementation of Metrolight and Menolinx technologies, CPC achieved 44% energy savings, partly by programming 250-watt lamps to operate with a default setting of 40% dimming. With a simple payback period of 2.8 years, CPC saw a 50% reduction in maintenance costs, mainly due to a double lamp life and the central monitoring system (Menolinx Systems, 2011; Metrolight, 2009).</td>
</tr>
</tbody>
</table>
| Key O&M Takeaways | • Automatic equipment scheduling  
• 44% energy savings  
• 50% reduction in maintenance costs  
• Simple payback period of 2.8 years |
# Appendix C
## Case Studies

### Los Angeles County Metro (LAC Metro)

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Transit Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Los Angeles County, CA</td>
</tr>
</tbody>
</table>

**Background**
The Los Angeles County Metro (LAC Metro) spends approximately $31 million per year in electricity and natural gas costs for rail propulsion and operation of maintenance facilities, terminals, and office. Electricity accounts for $30 million or 97% of those costs (Roman, 2009). LAC Metro operates five Metro Rail lines with combined daily boardings of nearly 360,000, and a bus fleet of over 2,400 vehicles (second largest bus fleet in North America) that averages one million daily boardings (LAC Metro, 2014). A number of divisions have led successful low- and no-cost initiatives to reduce energy use and improve efficiency. Through benchmarking, phone interviews, and site visits, LAC Metro found their biggest energy efficiency O&M issue to be the lack of coordination and communications between the LAC Metro central management and onsite facility staff regarding energy management, leaving each facility guideless on energy policies, goals, and strategies, or lack thereof. Furthermore, the staff were most concerned with keeping their facilities functional and safe—energy efficiency and conservation initiatives are not high priorities. This problem further disseminates within each facility, with each section operating independently and inconsistently without continued energy use monitoring, thorough maintenance improvement, common energy saving goals and tactics, as well as specific staff role assignment (LAC Metro, 2011). While facility managers with successful O&M programs are interested in working with others to develop energy reducing solutions, there is no central repository for energy management policies or a platform to share and leverage best practices (LAC Metro, 2011).

A study in 2006 found that lighting makes up a significant portion of overall energy use in warehouses and servicing and maintenance facilities. Considering the large, open, continuous space of these facilities, simply replacing lighting fixtures and incorporating occupancy sensors can significantly reduce energy usage and quickly recover the costs. Utilizing daylight can reduce artificial lighting costs as well as improve the quality of the work environment (Klimek & Murdoch, 2013). In terms of energy efficient thermal comfort, systems like radiant flooring, circulating fans for destratification, passive nighttime air circulation, heat venting and/or wind flow, localized active cooling or heating systems, and fans can eliminate the wasteful practices such as leaving bay doors open to cool off or using lone-standing space heaters (Klimek & Murdoch, 2013; LAC Metro, 2011).

### Key O&M Takeaways
- Installed occupancy and photo sensors for lights
- Upgraded light bulbs
- Utilized daylight
- Close gates and doors when the AC/heat is on
- Installed automatic digital thermostats with programmable setback temperatures
- Weather stripping on doors and caulk windows
### Sound Transit

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Transit Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Washington State</td>
</tr>
<tr>
<td>Background</td>
<td>To reduce their energy usage, Sound Transit (Washington State’s Central Puget Sound Regional Transit Authority) removed 33 data servers in 2011, eliminating the energy need to power this equipment 24/7 year-round. While initial capital costs were over $50,000, Sound Transit achieved payback just two years after in 2013. Computer low power mode programs were installed to put computers in a reduced power state during non-work hours and when unattended for extended periods. This method helps account for the individual habit of not turning off computers and other equipment when not in use. Capital costs were recovered by energy bill savings in just one year after installation and Sound Transit continues to benefit from this low-cost investment (Sound Transit, 2013).</td>
</tr>
</tbody>
</table>

#### Key O&M Takeaways
- Payback of 2 years
- Installed low power computer mode programs to put computers in a reduced power state during non-work hours

### Mississippi Department of Environmental Quality (MDEQ)

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Office Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Jackson, Mississippi</td>
</tr>
<tr>
<td>Background</td>
<td>The energy reduction efforts of MDEQ were spearheaded by an energy management team comprised of existing employees. Without any significant expenditure, operational adjustments to the buildings’ unoccupied periods and actual lighting needs, as well as ongoing employee energy awareness campaigns and periodic audits, resulted in immediate savings. MDEQ saw their energy consumption reduced by 37%, saving them over $140,000 per year in operating cost for energy. Even the most efficient lighting and air conditioning methods have to consider the preferences and habits of the building occupants to enhance cooperation and participation. Setting the most efficient lighting level and regulated temperature can result in employees resorting to additional personal lamps, fans, or heaters, defeating the very purpose of energy saving. To seek further energy use reduction opportunities, the MDEQ continues to monitor and analyze its time-of-day data from the building meters and energy management systems (Mississippi Development Authority, 2011). Once their energy reduction goals were set, the MDEQ team also generated data using the Mississippi Development Authority (MDA) Energy and Natural Resources Division’s Energy Monitoring and Controlling Solution (EMC) and benchmarked its energy performance using the Energy Star Portfolio Manager.</td>
</tr>
</tbody>
</table>

#### Key O&M Takeaways
- Reduced energy consumption by 37%
- Saved over $140,000 per year in energy operating costs
# Appendix C
## Case Studies

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Office Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Salem, Oregon</td>
</tr>
</tbody>
</table>

**Background**

ORDAS’s portfolio of 44 buildings of various types—including offices, warehouses, a library, and a data center—surpassed their energy reduction mandates (20% of 2000 levels) in 2010—five years before their 2015 deadline mandated by the Oregon Sustainability Act adopted in 2001 (Shepard, 2010). As an integral part of the agency’s larger Sustainability Plan, tracking and managing building performance focuses on two aspects: people and technology. Without proactive staff and occupant engagement and management, the tools and technology installation alone would not make the success.

Other than utility managers responsible for energy benchmarking and utility bill analysis to track progress toward energy savings goals, ORDAS also relies on Northwrite Inc.’s Energy Expert. The award-winning advanced energy information system is capable of modeling and predicting energy consumption in buildings (Northwrite, 2014). Through Energy Expert, ORDAS continuously collects and analyzes energy use data of the entire building and their operators are alerted of unexpected demand peaks, and the automation system and data loggers are used to identify system performance issues and excessive energy use.

**Key O&M Takeaways**

- Ensured building operators were well trained on any new technology and software
- Engaged occupants and tenants of office buildings through audits
## Appendix C
### Case Studies

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Office Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Stuttgart, Germany</td>
</tr>
<tr>
<td>Background</td>
<td>The transformation of the Z3 office building within the Stuttgart group headquarters began in 2012 with the goal of implementing innovative technologies that exceed the requirements of Germany’s Energy Conservation Act (EnEV). EnEV is Germany’s energy efficiency building code, which specifies that buildings reduce their primary energy demand by 80% by 2050 (Global Buildings Performance Network, 2013). Z3, a nearly zero energy use building, has already been awarded the German Sustainable Building Council’s Pre-Certificate in Gold (Kieback&amp;Peter, 2014b). A major upgrade included the use of technologies from Kieback&amp;Peter that involved the installation of their interdisciplinary building automation products. Kieback&amp;Peter installed their “LonWorks” technology, which enables the integration of systems into a single network (Kieback&amp;Peter, 2014a). For example, blind and lighting control in Z3 is integrated within the room automation system. To utilize natural sunlight, Kieback&amp;Peter’s technology includes shade control that automatically adjusts the slat angle of the blinds according to the position of the sun. On the other hand, artificial lighting is regulated by a presence detector, along with light intensity sensors (Research for Energy Optimized Building, 2014). Additionally, Z3 uses Kieback&amp;Peter’s TCF22 room control devices, which wirelessly integrates temperature sensors with individual room controllers. This system also allows employees to view the actual status of energy usage in the building and their individual offices right on their computers via a web user interface, therefore enabling them to modify behavior according to their own consumption (Kieback&amp;Peter, 2014b). While the project is still ongoing, the use of Kieback&amp;Peter’s efficient room automation systems significantly lowers energy consumption and makes it easy for staff to influence the indoor environment, ultimately helping Z3 set standards in sustainability.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key O&amp;M Takeaways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration of systems into a single network</td>
</tr>
<tr>
<td>Blind and lighting control integrated within the room automation system</td>
</tr>
<tr>
<td>Presence detectors</td>
</tr>
<tr>
<td>Light intensity sensors</td>
</tr>
<tr>
<td>System that allows employees to view the actual status of energy usage in the building and their individual offices right on their computers via a web user interface</td>
</tr>
</tbody>
</table>
## Appendix D
### National Certification Programs in Building Operations

<table>
<thead>
<tr>
<th>Organization</th>
<th>American Society of Heating, Refrigeration and Air-Conditioning (ASHRAE)</th>
<th>Association of Energy Engineers (AEE)</th>
<th>BOMI International</th>
<th>Northwest Energy Efficiency Council (NEEC)</th>
<th>US Green Building Council (USGBC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerequisite</td>
<td>Work experience and/or related degree</td>
<td>Work experience and/or related degree</td>
<td>NONE</td>
<td>Work experience and/or related degree</td>
<td>Work experience on LEED project</td>
</tr>
<tr>
<td>Focus Area</td>
<td>HVAC, Refrigeration Systems</td>
<td>Multi-disciplinary</td>
<td>Multi-disciplinary</td>
<td>Multi-disciplinary</td>
<td>Multi-disciplinary</td>
</tr>
<tr>
<td>Course Delivery</td>
<td>Exam only</td>
<td>Classroom training</td>
<td>Classroom training, online, self study</td>
<td>Classroom training and hands-on project at the facility</td>
<td>Classroom training</td>
</tr>
<tr>
<td>Training Hours</td>
<td>Self-guided</td>
<td>28 hours</td>
<td>120 hours</td>
<td>135 hours (Level I &amp; II)</td>
<td>8 hours</td>
</tr>
<tr>
<td>Continuing Education Unit Hours</td>
<td>45 hrs./3 yrs.</td>
<td>10 hrs./3 yrs.</td>
<td>18 hrs./3 yrs.</td>
<td>Level I: 5 hrs./yr. Level II: 10 hrs./yr.</td>
<td>30 hrs./2 yrs.</td>
</tr>
</tbody>
</table>
Appendix E

Types of Computerized Maintenance Management Systems (CMMS)

There are different software packages with which an agency can establish their CMMS system. The most common software types include:

1. Enterprise Asset Management Software package: All organizations have some sort of management system software like SAP or Oracle. These maintenance software applications are part of a larger system module (Koploy, 2013).

2. Stand alone packages: These can be customized to a degree while still offering the expected functions of a CMMS system. With a stand-alone system, it specifically looks for the management of assets and facilities such as the equipment maintenance costs, parts and labor entries etc. (Koploy, 2013). It is focused on what the facility and the facility staff needs but has a faster installation than a custom system.

3. Custom design system: Maintained to suit the facilities needs rather than fitting the facility into the packages specs. It is typically designed by a company or a third party specifically for the facility (Koploy, 2013).
References


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References (continued)


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Kieback&Peter (2014b). *Stuttgart - Zublin Z3.* Retrieved from http://www.kieback-peter.de/de-en/references/detail/?tx_kpreferences_referencedetail%5Breference%5D=750&tx_kpreferences_referencedetail%5Baction%5D=show&tx_kpreferences_referencedetail%5Bcontroller%5D=Reference&cHash=e856ce37a65b6e0b8a43104d7914b862

References (continued)


References (continued)


