RETROFITTING NINE GENERIC BUILDINGS TO ACHIEVE ENERGY STAR® DESIGNATIONS

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Two years ago, the staff at the Oak Ridge National Laboratory (ORNL) began a review of energy consumption in its facilities. During this review, it was observed that one building out of a group of 10 buildings that had similar construction and occupancy (referred to as the “generic” office buildings) performed much better in electricity consumption. This difference had been previously recognized when the energy efficient building, Building 1059, was awarded the ENERGY STAR® designation.

During the review of energy consumption, several important factors were noted when comparing Building 1059 to the other generic office buildings. All 10 buildings were built in the early 1990’s to very similar plans. They all had the same basic foot print and very similar materials of construction. Since the time of construction, each of the buildings had been occupied as general office or light laboratory usage, with no significant differences in the equipment or personnel loads. Yet, for all these similarities, Building 1059 consumed a fraction of the electricity of the other buildings.

ORNL’s Energy Management Team has implemented a project to retrofit the remaining generic office buildings to install lighting and heating, ventilation, and air conditioning (HVAC) control systems. This system will provide the capability to reduce energy consumption for these buildings by controlling electrical demand levels during normal and non-occupancy business hours. Successful completion of this project will allow ORNL to qualify additional buildings for the ENERGY STAR® designation and contribute towards compliance with the Energy Policy Act (EPAct) requirements.

This paper discusses the modifications required in both equipment and usage habits to reduce the energy consumption, as well as provides insight concerning lessons learned.

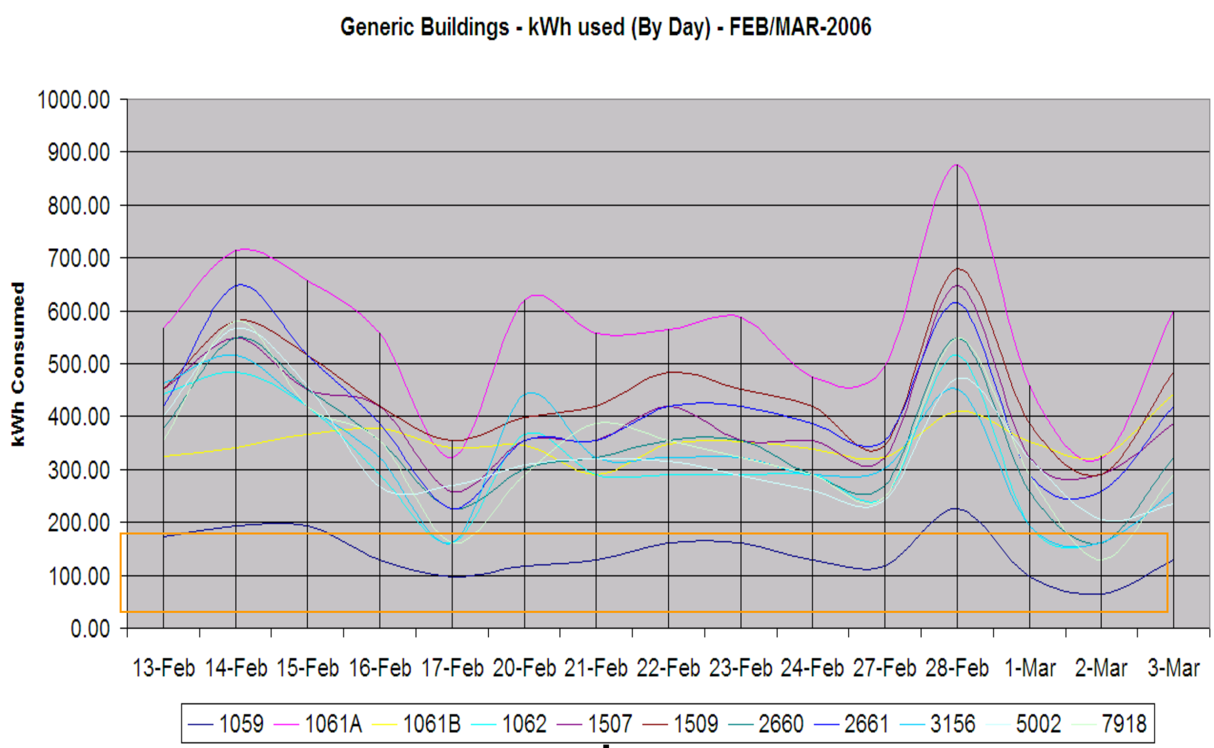
Description of the construction, operations, and energy use before and after in the generic buildings

Building 1059 was constructed in 1992 and is a two-story, all-electric, 6,998 square-foot office building with approximately 30 occupants. Many of the occupants utilize their offices to support research activities in nearby buildings. Significant electrical loads are for heating and air conditioning, personal computers, and office support equipment. Electrical usage in Building 1059 ranges between 120 to 192 kilowatt-hours (kWh) during a typical workday.

The remaining generic buildings are between 6,500 and 7,500 square feet and are also all-brick, 2-story with electric HVAC. Electrical usage in the remaining generic buildings is significantly higher than that of Building 1059. As displayed in Figure 1, Building 1059 consumes between 100 and 200 kWh per day with an average of 150. In comparison to the other generic buildings, Building 1059 consumes 2 to even 6 times less energy. This pattern has been consistent as long as data has been gathered for these generic buildings.

At the time the generic buildings were constructed, there was an attempt to incorporate building automation to control HVAC operation during the off-hours. These building automation systems had been problematic since the buildings were commissioned and were abandoned in all of the buildings except Building 1059. The system was kept in service in Building 1059, and whenever a particular component could not be repaired, the building occupants devised a work-around so that the desired functionality could be simulated by changes in occupant behavior. In other words, when the building automation failed, the occupants chose to change their actions to achieve desired lower energy usage. They incorporated building checks to ensure that HVAC was turned off during times when people were away from the building. They had a culture that encouraged turning off lights whenever rooms were empty, including turning off other employees' lights for them. Perhaps more importantly, they monitored the electrical consumption in the building and actively participated in keeping it down, as if they paid the bill directly.

It was this attitude of good stewardship that enabled the occupants of Building 1059 to achieve the ENERGY STAR®-worthy results, and it was with that in mind that the retrofitting project was undertaken. The desired outcome is not only to install a system capable of automating the use of the latest technology, but also to tap into the energy-conscious desires of the employees of ORNL.



1059- boxed in Orange

Figure 1. Generic Buildings

Equipment and building modifications made to the generic buildings to qualify for the ENERGY STAR® designation

This project used Building 1059 as the control group to modify nine other generic buildings to: 1) achieve nine additional correctly engineered lighting control systems; 2) provide the opportunity for ORNL to be awarded a number of additional ENERGY STAR® designations; and 3) begin to install the metering necessary to meet the upcoming EPAct 2005 mandates which require aggressive reductions in energy consumption.

In general, the project involves replacing the electrical circuit panels and breakers for lighting and HVAC control with breakers that are controllable and configurable to permit scheduling of electrical service to meet the needs of the personnel working in these buildings. Implementation of the project includes six major tasks:

1. Complete equipment installation activities
2. Schedule outages with affected building
3. Transfer building loads to the new system
4. Develop and implement the energy control schedules
5. Update electrical system documentation
6. Terminate project and document lessons learned

Each generic building has five or six electric panels. The panels are labeled A through F with A being the main panel controlling all electricity from its entrance into the building with distribution to the various panels within the building. Each of the panels (B through E or B though F—depending on the specific building) is retrofitted with a Square D PowerLink panel, and each panel is subsequently outfitted with motorized, switch-rated breakers.

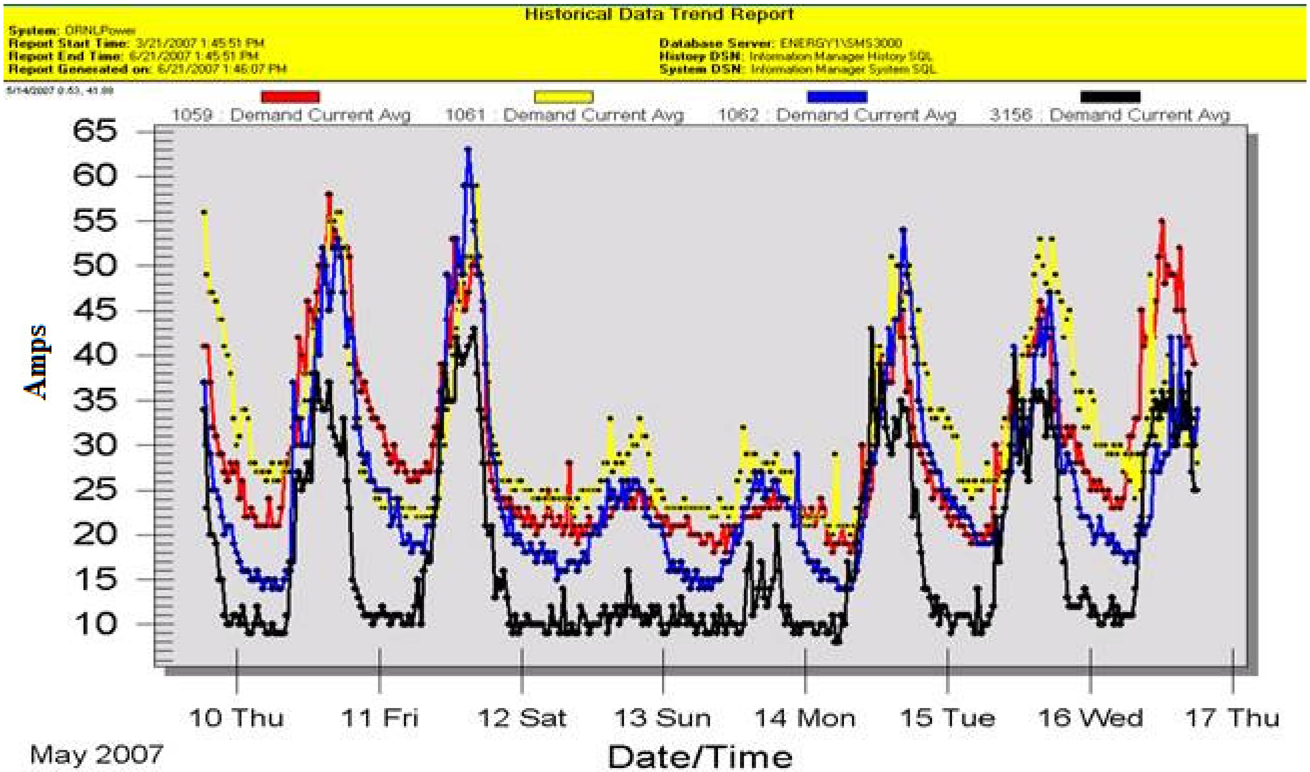
Each of the offices in the building has an occupancy sensor unit[1] mounted in the ceiling. These sensors are individually adjusted to ensure proper room coverage. The occupancy sensors are used to detect when occupants are using the offices. As long as there is activity in the office, the lights and the HVAC units continue to function. After the office is vacated the lights and HVAC units remain on for approximately 30 minutes or until there is new activity. This delay permits occupants to leave for short periods without the lights or HVAC units turning off.

There is a simple, documented process for retrofitting the standard panels and breakers with the PowerLink equipment. The process involves turning off the power to the panel, locking out the main breaker panel and removing the trims from the panels. Wires are removed from the breakers and the interiors are also removed. The interiors are measured to ensure trims and new interiors will properly fit into the panel. The new beldon conductor cable is installed to permit communication with each of the panels. Each subsequent panel is daisy-chained together for communication. Additional cable is needed if the panels are located on different floors. Once installed, the power is switched back on. Control software is loaded on appropriate computers and each panel and breaker is programmed.

Figure 2 presents the electrical consumption for 3 of the 5 buildings completed to date and shows a complete shift in consumption (refer to Figure 1). The newly-equipped and commissioned buildings exhibit performance comparable to Building 1059, and in some cases, exceed that performance. Additional data will be collected over the next two years to confirm the electrical consumption and cost savings. Successful demonstration of the newly achieved energy efficiency will qualify these buildings for the ENERGY STAR® designation.

[1] Clipsal occupancy sensors were used for this project.

Figure 2. Historical Data Trend Report



Schedule for the building modifications

As of the end of June 2007, five of the nine generic buildings selected for this project have been retrofitted (see Figure 3). Retrofitting of the remaining buildings will be complete by the end of CY 2007.

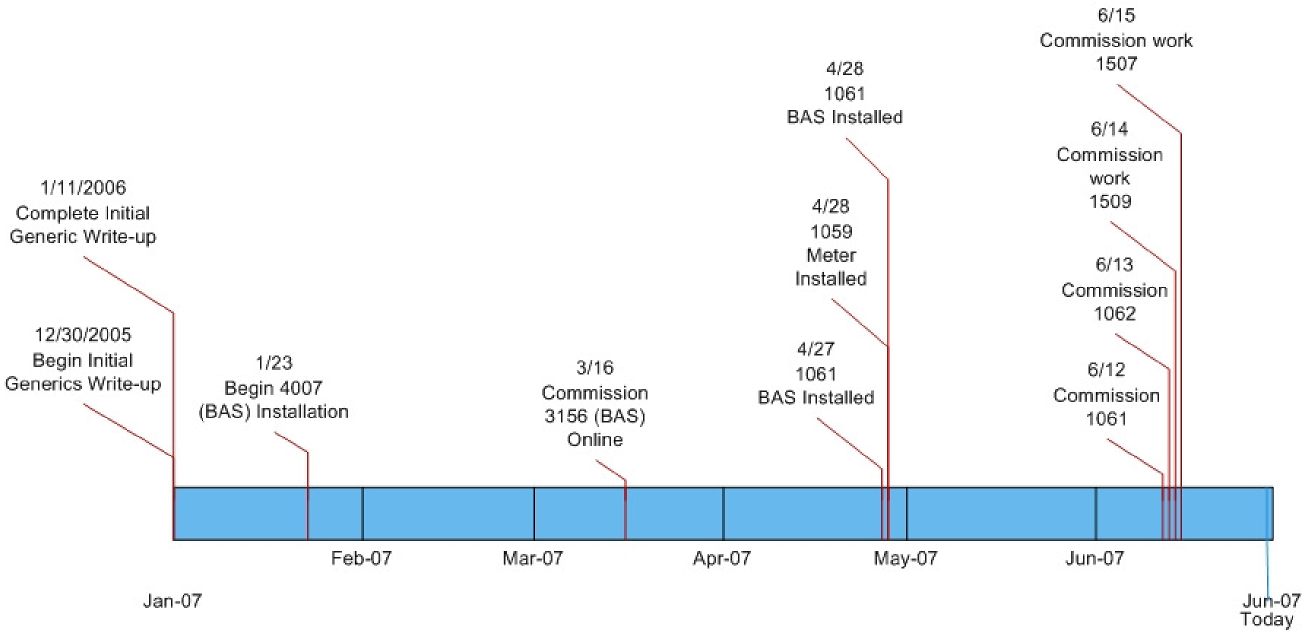


Figure 3. Time Line for Installation of Lighting and HVAC Control Systems in the Generic Buildings

Review of criteria for ENERGY STAR® designation

The U.S. Environmental Protection Agency's (EPA's) ENERGY STAR® is one of the most prestigious designations that a building can receive signifying accomplishments in energy savings. Earning two ENERGY STAR® awards to date is an example of ORNL's commitment to achieving excellence in energy performance. As one of the world's premier centers for research and development on energy production, distribution, and use, participation in ENERGY STAR® presents an excellent opportunity for ORNL to benchmark itself against other Federal facilities while reducing operating costs and striving towards compliance with Federal energy reduction requirements. Through execution of this project, ORNL hopes to achieve several other ENERGY STAR® designations.

ENERGY STAR® (www.energystar.gov) is best known as a designation for products that meet or exceed strict energy efficiency guidelines set by the EPA and the U.S. Department of Energy (DOE). The ENERGY STAR® label also identifies superior energy performance for America's commercial buildings and industrial facilities. To qualify for the ENERGY STAR® designation the interested party uses EPA's online rating tool, called Portfolio Manager (available at https://www.energystar.gov/istar/pmpam/). This online tool is employed to evaluate a building's energy performance using data related to the building's physical attributes, operating characteristics, and monthly energy consumption. The rating tool allows the user to benchmark buildings utilizing a linear 1 to 100 scale. The results can be used to help set energy performance targets and plan building upgrades. Buildings that score a 75 or higher and meet the remaining criteria shown in Table 1 are eligible to receive the ENERGY STAR® designation.

Table 1. Criteria for ENERGY STAR® Designation

1. The facility's energy performance for the past twelve months must be in the top 25 percent of its industry (as determined by the most current version of EPA's energy performance rating tool).
2. The facility must have safe lighting levels as recommended by the Illuminating Engineering Society of North America (IESNA) for industrial facilities and described in IESNA Lighting Handbook; 9^{th} Edition, Chapter 19.
3. The facility must satisfy the following environmental compliance criteria:
   a. no High Priority Violations of the Clean Air Act within the past 3 years,
   b. no significant violations involving on-site generation facilities within the past 3 years, and
   c. no criminal convictions or pleas within the past 3 years or current criminal investigations involving an employee or corporate officer for environmentally-related violations involving air emissions or on-site generation facilities at the facility.
4. A professional engineer licensed in the state in which the plant is located must certify that the information used to calculate the facility's energy performance score is correct.

Lessons learned

The following paragraphs present the main lessons learned to date during project implementation that will be used to improve our processes through completion of the project.

1. Having a process to use as a model is an important part of any enterprise-wide process.

   The 10 generic buildings in this group are almost identical in construction and square footage. This series of buildings provided an excellent scenario for studying both occupant behavior and building profiles. Once occupant behavior has been modeled and emulated, it can and will be rolled out to other facilities where the energy savings will be significantly greater.

2. Occupant input regarding traffic flow and facility usage needs to be validated.

   Occupant sensors were installed in the ceiling of the buildings to control lighting and HVAC. Once the sensors were installed and automating the lights and HVAC, building occupants determined that additional sensors were needed in other areas as the actual traffic flow varied from that perceived by the occupants. For future building installations, the traffic flow and facility usage will be physically monitored to accurately accommodate the needs of the occupants the first time.

3. Coordinate the equipment and Information Technology (IT) department efforts early in project.

   It is important for the project team to establish contact with the IT team during project formulation to ensure Internet Protocol (IP) addresses are obtained and all equipment is available to gather media access control (MAC) addresses and serial number data from the panels and meters. These data pieces are critical to allow the systems to operate on the ORNL campus network. The IT department assigns a "static" address (one that does not change over time) to each piece of building equipment to allow them to communicate to the server which collects the data. Inevitably there will be problems, such as IP conflicts, improper addressing, etc. Starting early allows for corrections and changes to assure a fully communicating system.

4. Be aggressive on automation set-up.

   Building occupancy was assessed using internal census data to determine normal operating hours for use in setting system schedules. Based on physical verification it was determined that occupant normal use hours were extremely conservative. Based on our observations of facility usage, the system schedule was adjusted to better serve the schedules of the buildings' occupants and achieve maximum cost savings.

Conclusions

Although this project is still in its infancy on the ORNL campus, the energy savings are already evident in the early data collected. With aggressive data collection and additional reviews with facility occupants as well as the maintenance staff, even greater savings will be achieved as the project is completed. Through implementation of this project ORNL will realize significant cost savings and achieve several other ENERGY STAR® designations.