Benchmarking and Best Practices in Power Management of Computers and Other Plug-Loads on Campus

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Abstract

Recognizing the impact of the growing plug-load energy consumption, the New York State Energy Research and Development Authority (NYSERDA) has funded the **Energy $mart**[SM] Offices program for the past 6 years to promote energy-efficiency measures, policies, activities, and education to reduce plug-load electric costs in offices, on campuses, and for school districts. At the same time, the State University of New York (SUNY) Energy Procurement group is also working with the Chancellor's Office in developing a strategic plan that includes reducing energy consumption on SUNY campuses. This plan encourages participation in the NYSERDA program as a quick turnaround, low-cost approach to reduce plug-load electric use on campus.

The NYSERDA program is unique in that it takes a comprehensive approach to plug-load equipment energy use in looking at business and non-business equipment. In addition, the program is the first to collect and use on-site plug-load equipment surveys and interviews to establish benchmarks that identify standard practice and best practices for college campuses to encourage plug-load efficiency.

The paper will describe the approach used to determine plug-load electric use and energy-efficiency opportunities on college campuses and then present the results of the benchmarking of best practices in plug-load efficiency. The intent is to encourage colleges and universities to adopt these best practices in reducing the fast growing plug-load electric costs on campus.

Introduction

There are many definitions of "benchmarking." After reviewing the various definitions, the following posed by Wikipedia (a free on-line dictionary) is fairly comprehensive and descriptive of this project to benchmark best practices for the efficient use of plug-load equipment on campuses:

> "Benchmarking (also "best practice benchmarking" or "process benchmarking") is a process used in management and particularly strategic management, in which organizations evaluate various aspects of their processes in relation to best practice, usually within their own sector. This then allows organizations to develop plans on how to adopt such best practice, usually with the aim of increasing some aspect of performance. Benchmarking may be a one-off event, but is often treated as a continuous process in which organizations continually seek to challenge their practices."

Data collected through interviews and on-site equipment surveys at 28 NYSERDA **Energy $mart**[SM] Offices projects completed through the end of 2006 on college campuses are being used to develop best practice benchmarks for plug-load equipment use. Those benchmarks include measures such as quantities of equipment and electric use of that equipment per administrative staff person, faculty member, and student. The benchmarks consider best practices in terms of energy-efficiency actions taken to reduce plug-load

electric use such as implementing computer power management in computer labs and offices. The benchmarks can be used by colleges to determine how well they are doing in implementing plug-load efficiency measures, policies, and procedures compared to standard practice and best practices for a group of similar colleges. With that information, campus decision-makers may be even more motivated to fully implement recommendations from the project team to help them improve their effectiveness in controlling plug-load electric costs.

Why Benchmark Plug-Load Energy Efficiency?

Energy managers report that despite implementing building energy-efficiency projects that target lighting and HVAC systems, electric bills continue to increase due to the growth of plug-load equipment. Personal computers and other office equipment are estimated to be the fastest growing energy uses for the commercial sector through 2030 according to the Energy Information Administration—Annual Energy Outlook 2006 Report. These plug-loads are estimated to grow at least three times faster, at 3 to 4 percent annually, than energy consumption for other end-uses such as space heating, which is expected to grow about 1 percent a year.

While the office sector is the most computer-intensive sector, educational facilities are the second most computer-intensive sector. In that context, business and non-business plug-loads are major contributors to the growth in energy costs for administrative staff, faculty, residence halls, and classrooms on campus. These plug-loads include computers, copiers, printers, faxes, refrigerators, washing machines, vending machines, task lights, space heaters, and other electronics. These business and non-business plug-loads can account for at least 20 percent of the electric use in administrative buildings and residence halls.

Private and public universities and colleges in NYS include approximately 240,000 equivalent full-time employees (FTE). The conservative estimate is that there are 120,000 PCs for that educational sector. With approximately 300 colleges and universities, this estimate equates to an average of 400 PCs per school, which is a reasonable estimate for staff computers. In addition, there were 1,125,000 students enrolled in the private and public colleges of New York State during the Fall of 2004. If only 10 percent of these students are housed on campus, there is an additional 112,500 computers and associate plug-load equipment that could be power managed.

NYSERDA's Energy $mart Offices Program

The campus projects completed through NYSERDA's **Energy $mart**[SM] Offices Program were used to develop the benchmarks of best practices that will be used as benchmarks for previous and new participating campuses. The NYSERDA program is designed to reduce electric costs for offices and educational institutions by encouraging best practices in procurement, power management, and operation of plug-load equipment. The project team members, led by PA Consulting Group, collect and analyze data on plug-load business and non-business equipment and operating practices to estimate energy use and potential savings for each site. The project team recommends low-cost/no-cost measures that include tested power management tools and control devices. To facilitate implementation, the PA team provides support to the project sites to develop energy-efficiency policies and programs that include staff education and outreach, student activities, policy directives, and procurement specifications. The PA team includes energy analysts and computer power management consultants who take a comprehensive approach to assessing plug-load equipment savings opportunities.

The recommended approaches to reducing plug-load electric use to achieve **Energy $mart**[SM] Offices plug-load efficiency will include a combination of short-term and long-term measures including:

- **Power management:** ensure that all applicable ENERGY STAR® office equipment such as PC monitors (and computers where applicable), printers, and copiers are enabled to go into "low power" or "sleep mode" when not in use.

- **Power off:** educate staff to turn off plug-load business equipment (PCs, monitors, printers, copiers, speakers, task lights) after hours and when not being used for several hours. Use timers to control the operating hours of other inefficient equipment such as large coffee makers that heat water 24 hours a day, water coolers that have hot and cold water taps, and other plug load equipment.

- **Purchase "best" ENERGY STAR equipment**: develop and enforce purchasing/leasing standards that specify the most efficient ENERGY STAR office equipment including copiers, printers, task lighting, vending machines, water coolers, clothes washers, and other plug-load equipment.

Data Collection Methodology Used to Develop Benchmarks

In developing the benchmarks, the objective was to identify indicators that were easy to calculate and compare across similar educational facilities. In addition, the data needed to be easily accessible and not require detailed engineering analysis to minimize the costs of developing and maintaining the benchmarks. The data was organized by administrative and support staff, faculty, student use areas (such as labs), and residence halls. The data collection and analysis process is fairly comprehensive and consists of several steps:

1. Request key data on Form A. Information Request that include quantities of major plug-load equipment, average electric cost (cents per kWh), number of staff, number of full-time faculty, student enrollment, students living on campus, total number of computers on the network, and current policies.
2. Schedule on-site data collection with project coordinator for the site and review the campus web-site to gather key data and information on key buildings and plug-load equipment, computer labs, and residence halls.
3. Present project and conduct group interviews (using an interview guide) while on site with staff from information technology (IT), auxiliary campus services, Residence Life, facilities or energy management, faculty, procurement, and other key functional areas.
4. Conduct an on-site equipment survey of a representative sample of buildings and equipment to estimate quantities of plug-load equipment by type and to determine equipment operating characteristics including current power management settings for computers, copiers, printers, and other equipment.
5. Conduct an after hours survey of the primary administrative buildings and a sample of faculty offices to assess equipment quantities, equipment shutdown, and power management.
6. Make multiple inspections of all major computer labs to determine levels of student traffic/utilization of computers by students and power management settings and shutdown.
7. Observe representative residence halls including common areas and student rooms in residence halls (when possible) to assess levels of plug-load equipment.
8. Request additional information from project site staff to support the analysis including computer utilization reports, equipment inventories and model numbers (computers, copiers, printers, vending machines, clothes washers), and energy costs by building and month (if available).
9. Analyze the potential savings using a variety of calculators designed for this project in addition to those available on the ENERGY STAR web-site.
10. Present the results to the key technical staff and discuss any new data or changes before finalizing the data and the report.

11. Conduct a follow-up survey to determine what measures have been implemented and estimate the actual implemented savings.
12. Summarize the data from all the projects by size and type (community college or university) to determine key statistics for benchmarking best practices for plug-load energy-efficiency.

College and University Sample and Key Data

The benchmarking of best practices in plug-load equipment use requires the estimation of some key statistics. In particular, many of the statistics such as energy use or number of campus-owned public use computers are analyzed for the number of students enrolled. The numbers of students living on campus are relevant to the number of washing machines and refrigerators in dorm rooms. At the same time, it is important to look at other plug-load equipment such as individual printers and copiers for numbers of administrative and support staff and faculty.

Table 1 lists the colleges that are included in the plug-load equipment surveys and the key statistics for each of the colleges. These statistics were gathered from a variety of sources including the initial information request (Form A), review of the campus web-site, interviews with key staff, and other reference data. These key statistics were presented to all of the participants with the preliminary results of the **Energy $mart** Offices project data collection and analysis.

Although the benchmarking of best practices includes all types of plug-load equipment, the numbers of computers or computer users are used as the basis for many of the benchmarks. For example, there may be operating staff that do not have computers and do not use other business plug-loads such as copiers, and printers, who are not considered in the benchmarks.

It is also important to note that the campus plug-load benchmarks should be developed separately for 2-year community colleges that do not have residence halls and for those larger universities that do include students living on campus in residence halls. Plug-load electric usage per student for colleges with residence halls are much higher that colleges without residence halls due to the considerable business and non-business plug-loads that students use in their rooms. Unfortunately, many campuses do not separately meter and break out electric use by building so the data available is typically total annual electric usage for the entire campus for the year.

The program for the 2006 and 2005 projects was enhanced over the previous year in that the plug-load equipment survey became more comprehensive in looking at additional major plug-loads across the campus. Given the changes in the program over the past few years and because the projects were completed more than 3 years ago, PA Consulting Group's market analytics staff is completing a follow-up survey to identify the current practices in plug-load efficiency for project sites or campuses with data collection completed before 2006. The survey will review all of the recommendations made originally by the project team and identify current data and practices for plug-loads. The survey will also fill in data gaps in that the earlier campus projects were less comprehensive in addressing all plug-loads than the current program. Recognizing that the NYSERDA plug-load efficiency program has influenced these projects to implement plug-load efficiency measures, it is still appropriate to identify best practices that were put into place with and without the program influence.

Table 1: Summary of College and University Participants

Project Year	NYSERDA Energy $mart Offices Project Sites	Total Full-Time Student Enrollment	Students in Residence Halls	# of Staff and Faculty Computers	# of Campus-owned Public Use Computers	Estimated Total # of Computers on the Network
2006	SUNY Potsdam	4,300	2,180	1,445	600	4,225
2006	SUNY Canton	2,700	900	500	400	1,800
2006	St. Lawrence University	2,300	1,900	780	550	3,230
2006	Clarkson University	3,000	2,030	500	350	2,880
2006	SUNY IT	2,500	500	260	400	1,160
2006	SUNY ESF	2,100	900	450	200	1,550
2006	SUNY Cortland	7,300	3,000	1,150	1,700	5,850
2006	SUNY Brockport	6,500	2,550	2,000	775	5,325
2006	SUNY Geneseo	5,500	3,260	865	900	5,025
2006	Cornell Agr. Experiment Station	90	0	400	300	700
2006	Rensselaer Polytechnical Institute	6,400	2,900	2,750	530	6,180
2006	SUNY New Paltz	7,600	2,740	1,300	670	4,710
2005	SUNY Oneonta	5,800	3,300	1,200	450	4,950
2005	SUNY Cobleskill	2,500	1,600	320	420	2,340
2005	Alfred State College	3,300	2,300	1,000	500	3,800
2005	SUNY Binghamton	13,860	6,000	2,000	350	8,350
2005	Buffalo State College	11,000	1,850	1,200	1,200	4,250
2005	SUNY Fredonia	5,400	2,500	1,100	300	3,900
2005	SUNY Albany	17,200	6,000	4,400	2,200	12,600
2005	Ithaca College	6,000	4,300	1,425	500	6,225
2004	University at Buffalo	23,000	7,000	7,000	1,000	15,000
	Total Colleges and Universities	**138,350**	**57,710**	**32,045**	**14,295**	**104,050**
2006	Mohawk Valley Comm. College	2,000	500	750	600	1,850
2006	Monroe Community College	10,000	400	900	2,000	3,300
2005	Dutchess County Comm. College	8,000	0	440	500	940
2005	Tompkins Cortland Comm. College	3,000	400	340	400	1,140
2005	Genesee Community College	4,400	0	500	480	980
2004	Finger Lakes Community College	4,900	0	250	NA	750
2004	Jefferson Community College	1,400	0	NA	NA	750
	Total Community Colleges	**33,700**	**900**	**NA**	**NA**	**9,710**
	Total	**172,050**	**58,610**	**NA**	**NA**	**113.760**

Source: NYSERDA New York Energy $mart Offices Projects: Colleges and Universities Plug-Load Efficiency Savings Estimates, Updated by: Carol Sabo, PA Government Services, Inc. on June 11, 2007

Trends and Benchmarks for Plug-Loads and Energy-Efficiency Opportunities

For purposes of determining standard or typical practices, the PA team felt it was appropriate to use the data collected for the 13 most recent campus projects completed in 2006. At the same time, it is useful to

compare the data from projects for previous years (before 2006) to show how plug-load efficiency trends have changed in the past few years. In particular, there have been significant changes in more efficient use of computers and monitors that include:

- campuses are ordering more efficient LCD monitors instead of CRT monitors when purchasing new monitors
- the percentage of computers with monitor power management enabled has increased and is widely accepted once the savings opportunities are identified
- the percentage of computers with computer power management (system standby or hibernate) is increasing and becoming more acceptable for new computers that may be shipped with both monitor and computer power management enabled
- more campuses are promoting laptops to students and going wireless, which may reduce the need for as many public use computers.

Figure 1 is a breakdown of the potential savings opportunities that were developed from the 2006 campus plug-load efficiency projects categorized by type of plug-load equipment.

Figure 1. Breakdown of Plug-Load Equipment Savings Opportunities by Category - Estimated Savings of 15,900,000 kWh for 13 Campus Projects
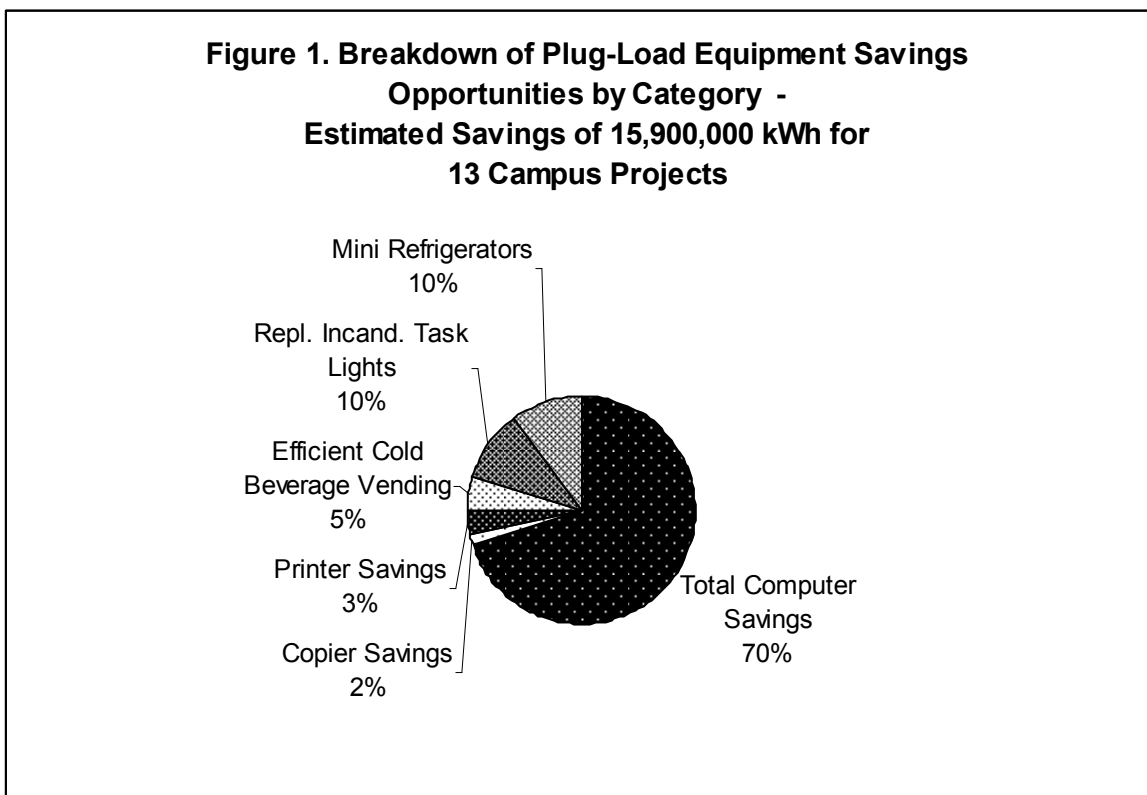
Table 2 presents some of the key benchmarks, based on the most current data for the 2006 campus projects. The benchmarks of some best practices are bolded for that statistic. For example, low average kWh per student enrolled and high levels of monitor power management represent best practices.

Table 2. Plug-load Use and Efficiency Benchmark Measurements for 2006 Universities

Benchmarks for Major Plug-Loads (n=13 projects)	High	Average	Low
Total Campus:			
Average Total Electric Use (kWh) per Student Enrolled	10,256	5,416	**2,870**
Average Computer Electric Use (kWh) per Student Enrolled	479 kWh	346 kWh	**186 kWh**
Avg. Potential kWh Savings per Computer for Computers	417 kWh	221 kWh	**117 kWh**
Avg. Potential kWh Savings per Computer for Other Loads	176 kWh	95 kWh	71 kWh
Campus Computer kWh as a % of Total Annual kWh	19%	10%	4%
Potential kWh Savings as a % of Total Computer kWh	68%	46%	**34%**
Staff including Administrative and Faculty:			
Average # of Staff Computers per Student Enrolled	0.43	0.21	0.10
% Admin. Staff with monitor power management enabled	**86%**	49%	0%
% Faculty with monitor power management enabled	**84%**	45%	0%
% of All Staff computers that are powered off at night	**99%**	60%	20%
Average # of Administrative staff per copier	45	16	6
Average # of Administrative staff per printer	6	2	1
Student Use Computers (Labs, Classrooms):			
# of Public Use Computers per Student Enrolled	0.24	0.15	0.08
% of Monitors that have Power Management enabled	**95%**	54%	12%
% of Public Use Computers that are Powered Off at night.	**90%**	28%	1%

In considering the statistics presented in Table 2, it is useful to consider differences in the universities that may influence some of the high and low data. For example, the highest average kWh annual use per student of 10,256 kWh is for a university that includes significant research equipment. In addition, the college with 19% computer kWh usage as a portion of total annual kWh is a college with few students in residence halls.

Process Related Best Practices

In addition to the examples of quantitative benchmarks discussed in the previous section, the project team has identified examples of policies, procedures, and programs that represent best practices. In most cases, these are best practices that are being used by one or more of the **Energy $mart** Offices participants.

In a few cases, the best practices were identified from research of colleges and universities outside of New York State, but were included in recommendations to the NYSERDA project campuses.

General

- Have a widely publicized energy-efficiency policy that includes plug-load equipment purchasing, operating, and power management procedures
- Create a sustainability committee on campus to implement policies and programs that have representatives of administrative staff, faculty, student affairs, residence life, information technology (IT), procurement, facilities, energy, and other key functions
- Include language in employment agreements that staff will abide by specific policies for plug-load equipment usage

Tracking and Monitoring

- Provide submetering to track, analyze, and publicize electric use data in specific buildings including administrative building, faculty offices, and residence halls
- Track and maintain an inventory of plug-load equipment owned by the college organized by use with models and types including computers, monitors, copiers, printers, vending machines, washing machines, and other major plug-loads to facilitate plug-load electric use analysis
- Track and monitor the utilization of computers in public use areas to identify computer labs that may be shut down during periods of time or computers that may be shifted to other areas or eliminated
- Use a print management system to track and reduce waste in unnecessary printing

Procurement Policies and Procedures

- Centralize and standardize procurement of major plug-load equipment owned by the college or university
- Specify the most efficient ENERGY STAR models of equipment particularly for copiers and large multifunction devices, water coolers, vending machines, task lights, and appliances
- Specify 80plus computers and those that will meet the new ENERGY STAR standard when adopted and equipment are available
- Implement a procedure to ensure all new computers and monitors, printers, and copiers have power management settings enabled appropriately for the users before installation
- Replace all CRT monitors with LCD monitors that use less power and generate less heat
- Purchase laptops instead of desktop computers for appropriate computer users
- Eliminate unnecessary speakers with computers since they are often left ON when not in use

Computers and Monitors

- Implement both monitor power management and computer power management (system standby or hibernate) on all appropriate staff (administrative and faculty) computers and in computer labs
- Require/provide students with laptop computers and wireless systems to reduce the number of desktop computers in computer labs and classrooms
- Develop a program that encourages students to implement monitor and computer power management on their personal computers, particularly those used in residence halls

- Provide faculty members with laptops for their use (instead of desktops) that they can plug in and use for classrooms
- Provide remote access to computer labs for students so computers can be powered off after hours in computer labs
- Reduce unnecessary servers and replace necessary servers with new efficient servers
- Provide staff with VPN capability to access the campus network from home instead of leaving desktops running for remote access
- Restrict the use of 3-dimensional screen savers that may actually double the power output of the computer and establish a low-power screen saver with college logo, if screen savers are desired

Powering Off Equipment

- Assign responsibility to key staff to check that computers and monitors, printers, copiers, and other related equipment are turned off after hours
- Ensure that ENERGY STAR copiers are purchased that include an Auto Off feature and that feature is set to power down after a reasonable amount of inactivity (typically an hour for most new copiers)

- Require staff to use their power strips to plug-in computers (including laptops), printers, and task lights and turn off the power strips after powering down computers

Residence Halls

- Install all front-loading ENERGY STAR washing machines in laundry areas of residence halls
- Use coin-operated or smart cards to charge for use of washers and dryers to ensure more efficient use of appliances by students in residence halls
- Establish policies to reduce electric use from minifridges and microfridges by requiring/providing ENERGY STAR models and limiting the size and number of units per room
- Require/provide compact fluorescent lights in task lights in student rooms
- Conduct surveys of residence halls to identify the amount of personal plug-load equipment brought onto campus by students living in the residence halls
- Develop a program to encourage students to implement monitor and computer power management settings on their computers
- Establish a competition among dorms that will educate and encourage students to reduce plug-load electric usage in residence halls
- Provide common area printers with appropriate energy saver settings and print management controls to reduce the use of individual printers in student rooms

Other Plug-Loads

- Replace all cold beverage vending machines with ENERGY STAR Tier II models as soon as possible
- Use vending misers to reduce the electric use of cold beverage vending machines until they can be replaced
- Replace large coffee makers that heat water 24 hours a day or use timers on them to power them off after hours and turn them on in the morning
- Remove the hot water tap from water coolers that include both hot and cold water taps

- Ensure all task lights have compact fluorescent bulbs to replace incandescent lightbulbs
- Establish policies to eliminate individual space heaters and fans and minifridges unless necessary to maintain comfort levels or offer more efficient units or ENERGY STAR models as alternatives

Lessons Learned

The project team's experience in collecting and analyzing plug-load equipment data over the past 5 years has been very valuable in developing benchmarks for standard practice and best practice. The campus projects have all been very appreciative of the information and most are moving forward to implement recommended low-cost/no-cost plug-load efficiency measures based on the project savings estimates. They are also quite interested in the benchmarking data and often ask how they compare to other similar universities in plug-load usage. Those who are interested in collecting similar data should be aware of the following issues:

- It is necessary to analyze administrative staff and faculty separately because they have different behavior and different issues in changing their behavior relative to power management and powering off their computers. At the same time, most colleges do not have data readily available to separate out the total number of computers for each of the two groups. In some cases, it has been necessary to obtain a staff directory and count names of staff members to get a reasonable estimate of the number of computers for faculty and administrative staff.
- A key input to most savings calculators for computers and monitors is the percent of time that the computer is not being actively used and can go into low power or "sleep" mode. Default values for administrative staff are available but the utilization of public use computers in computer labs varies greatly. In some cases, the IT group does track that data using network tools. In most cases, the project team conducted multiple spot checks of major computer labs to record the percent of computers that were powered on and being actively used as an estimate of active use of those computers.
- All of the average savings estimates for computer power management and monitor power management that are on a per-computer basis include some existing level of power management. These per-unit estimates allow the project team to easily weight the sample back to the appropriate population of computers to get campus-wide savings estimates. As a result, the per-unit savings estimates are usually smaller than those reported by EPA ENERGY STAR's power management web-site (**www.energystar.gov/powermanagement**) of $25 to $75 per computer.
- It is important to obtain monitor power management and computer power management settings from a sample of each group—administrative staff, faculty, computer labs, and residence halls. The campus IT group may be able to identify settings for various computer labs and staff if they use the same image for each computer type. In addition, there is software such as EPA's EZ-SAVE that has the capability to poll computers on the network to get monitor power management settings for the group of computers, but most IT staff were reluctant to go through that process. Ideally, the equipment survey will include checking the power management settings on a sample of computers for administrative and faculty members with their permission. The project team can do that quickly with minimal interruption of productive time of staff. Settings for public use computers can be checked with the assistance of an IT staff person since they usually require a pass code for logging on to the computer. Students in residence halls have been surveyed in rare cases with the assistance of a residence life staff person. In many cases, conservative estimates of student computer operation and power management are made from national data, coupled with intelligence on what types of computers are being purchased or brought from home by students in residence halls. While newer

computers being purchased by students often come with power management enabled, students are also likely to override those settings, so it will become more critical to survey student computers in residence halls.

- Although there are a number of other plug-load equipment that are recorded, the focus of the equipment survey and the analysis are on the major savings opportunities that include computers, copiers, printers, vending machines, task lights, and individual refrigerators. Other plug-load savings opportunities that offer limited savings are mentioned but not quantified. These may include powering off computer speakers, using timers on large coffee makers, shutting off hot water taps on water coolers that also have hot water, and removing or using more efficient alternatives to space heaters.

- It will be critical to keep up with new opportunities for plug-load savings and incorporate them into the program. For example, there are new standards and new equipment that will be available such as 80 plus computers and more efficient computer servers. The market is being transformed to implement monitor power management but much of the growth of electric will be in plug-load equipment on campus. The challenge is to help campuses identify ways to reduce those plug-load electric costs while giving them reliable estimates of the savings that can be achieved from those measures.

- IT staff are key to implementing a majority of plug-load savings on campus and must be directly involved in the project. In addition to providing key data to estimate potential electric savings, the project serves to educate IT staff on the importance and ease of implementing power management on campus monitors and computers and the potential electric bill savings benefits for their campus. The NYSERDA project team includes an expert in computer power management who can address IT's actual and perceived technical barriers to implementing computer power management, in particular. In addition, IT staff may have direct responsibility for specifying copiers and multi-user printers on campus.

Next Steps

The best practice and standard practice benchmarks will be updated after completing the follow-up surveys with the earlier projects. The results will be provided to participating campuses of NYSERDA's **Energy $mart^{SM}** Offices program along with the current situation for their campus as a comparison. Other industry experts on plug-load efficiency will be asked to review the benchmarking measures and best practices to identify useful additional metrics. A possible future activity is to develop a rating system along the line of LEEDS that certifies campuses as meeting certain levels of plug-load efficiency practices.