Measuring Campus Performance

A Case Study Analysis

Many college campuses are billed for utilities based on a small number of meters shared by multiple buildings. As a result, utility tracking systems provide aggregate usage measurements, instead of providing building-level data. This approach to utility measurement often reduces utility rates or reduces installation costs for district heating/cooling systems, but it obscures the true performance of individual buildings. "Measurement is the first step that leads to control and eventually to improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it."[1] Measuring utility use for individual buildings is a necessary step towards making college campuses more resource efficient through targeted improvements for poor-performing buildings.

The following guide is intended to provide you with an understanding of the value of submetering on a campus and how to set-up and maintain a submetering program. Case studies from four prominent schools are included to illustrate different solutions for campus submetering. To learn more about reducing energy and water consumption on campuses through benchmarking, upgrades and behavior change, review the companion document *Campus Benchmarking Guide*.

Benefits of Submetering

Submetering significantly enhances building performance monitoring capabilities by providing a higher resolution to resource use across campus and bringing to light the energy and water consumption of individual buildings and/or systems that would otherwise remain in the dark. Submetering technology can measure virtually any metric of energy or water consumption and be installed on both new and existing buildings.

The chief benefits of submetering include:

- Understanding utility usage patterns
- Identifying under-performing buildings and prioritizing efficiency improvements
- Revealing water leaks and failing components to help guide preventative maintenance and timely adjustments
- Verifying performance of implemented efficiency improvements and calculating actual return on investment
- Educating students and staff by providing data visualizations to drive behavior changes
- Evaluating the accuracy of utility bills to reduce billing errors and assess billing rates

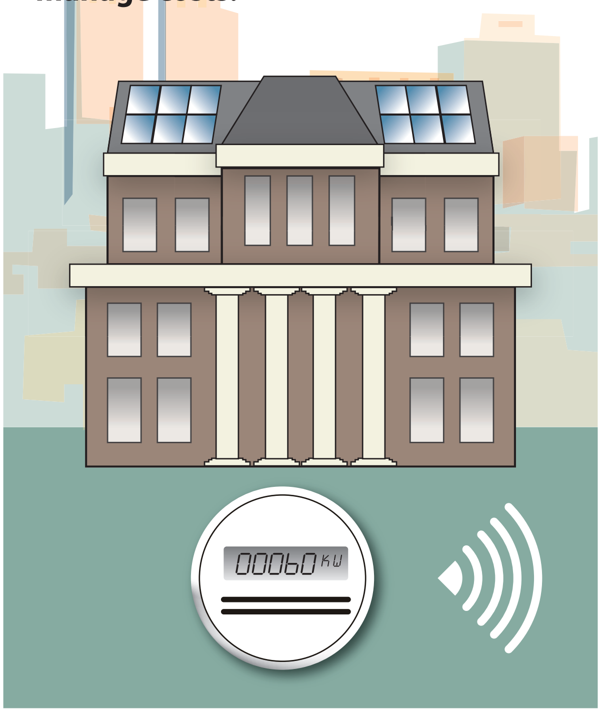
More utilities are now installing smart meters which offer additional benefits. Smart meter benefits include:

- Enhanced data driven tools to manage use and costs (e.g., gamification)
- Further enhancements to demand response programs
- Integration of distributed energy resources such as solar/distributed generation

> Submetering is the direct measurement of a commodity sold by a utility's master meter. Submetering includes only that which is measured on the billing. i.e., it includes no distribution costs. (ASHRAE)

1. H. James Harrington

Smart meters allow monitoring of energy usage in real time and can help manage costs.



Makes integration of **SOLAR** energy with the grid easier.

Manage your **COSTS** with more detailed information on your energy use.

REMOTE activation or transfer of service means no more waiting.

Make wiser energy decisions that help the **ENVIRONMENT**.

Get real-time billing information based on **ACTUAL USAGE**. No more estimated bills.

A smart meter will notify the utility when the power goes out. That means faster **RESTORATION** and fewer outages.

Prioritizing Existing Buildings to Submeter

The following buildings are great candidates for submetering:

- Resource-intensive buildings including dining halls, laboratories, natatoriums and data centers
- Buildings for which energy usage cannot be estimated
- Buildings with a high probability for immediate savings to create an incentive for reinvestment (*FEMP, 2015*), often identified as buildings with the oldest lighting and HVAC controls technology
- Buildings with historically volatile use and/or utility patterns

Buildings planned for demolition, closure, or sale within the next 5 years may be poor candidates for submetering. Buildings served by district heating/cooling systems are more challenging to submeter but may also be the best candidates for submetering.

Building the Case for Small Buildings

Large campus buildings over 50,000 square feet are often the first choice for energy monitoring and retrofits because they can consume the most resources. However, taken together, small buildings can account for a high percentage of cumulative utility use when compared with larger buildings making them tremendous candidates for energy improvements. If small buildings do not make it onto the initial metering list, energy and water efficiency upgrades may still be deployed for substantial savings. However, it is encouraged that these small buildings be submetered in order to accurately calculate and report savings and return on investment, thereby validating the value of the efficiency projects and gaining future funding approval for new projects.

To assess your campus portfolio, utilize the companion document *Campus Benchmarking Guide*.

Designing a Metering Plan

There is no one-size-fits-all approach to submetering. Each building should be fitted with a customized metering system that corresponds to the utilities consumed and designed to work within the campus-wide submetering program. The granularity of your campus utility measurement system should align with your institution's utility reduction goals, budget and data management capabilities. Thoughtful planning will generate submetering system designs that provide the level of data required for each building and building system, while using consistent technology simplifies maintenance and permits future expansion.

Develop a Pilot Program for Submetering Existing Buildings

Implementing a successful submetering program throughout a campus can be challenging. Barriers to successful submetering programs include high installation costs, incompatible technologies and incomplete planning. Do not buy a bulk quantity of submetering equipment, then expect that you will be able to make it work. Verify that a system works with the culture and infrastructure of your campus, then plan how to best deploy it throughout your campus.

Installing a submeter with the supporting data infrastructure will provide valuable insight about the submetering process, which will inform future submetering projects for your campus. Begin by installing a small quantity of submeters as a pilot study. Document each step of the process, including the cost of components and time required to install and configure the system. The first submetering project will be the most challenging; and it will also be the most educational.

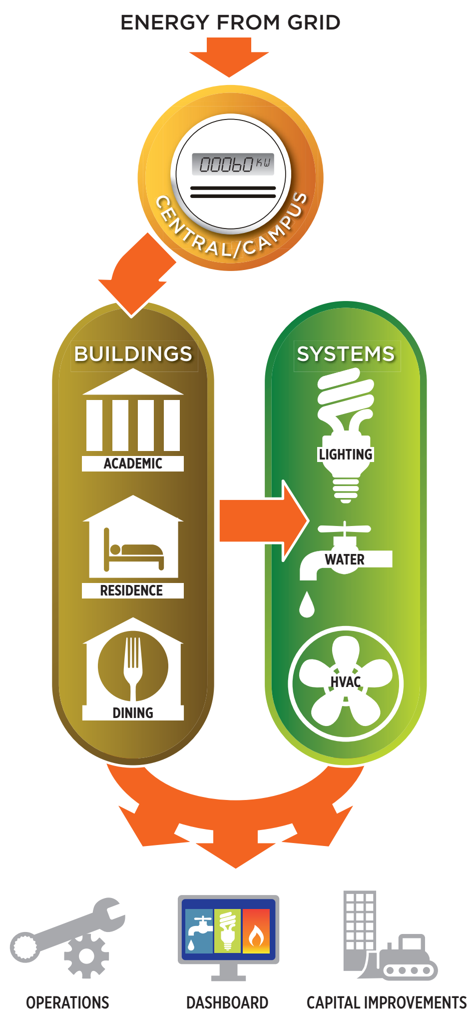
Establish a Metering Policy for New Buildings

As with all building systems, the most cost-effective time to improve the metering system for a building is during its design. Establish a policy to individually meter all utilities for all new buildings. Ensure that new meters have advanced metering infrastructure (AMI) capabilities.

Building Level

Installing submeters on a building-by-building basis is the recommended approach, with one meter measuring every utility entering the building. In this configuration, a building that consumes water, electricity and natural gas should have three meters. Since electricity typically accounts for 80% of total energy costs and electricity submeters are typically less expensive than other energy submeters, many schools submeter electricity initially then meter other energy sources subsequently. Building-level submetering helps campus staff allocate energy costs among departments. By comparing annual building energy consumption to national or local datasets with similar building types, under-performing buildings can be identified for energy improvements.

For large or complex buildings, building-level data may not be sufficient to conclusively reveal which systems are consuming resources. Building-level data collected at short intervals (e.g. 15 minutes) reveal surprising details about system-level consumption patterns. Adding disaggregation analytics and collecting data at smaller intervals can unlock usage patterns for nearly any building. Even if system-level submeters are installed, it is still recommended that building level data is collected by one of the submeters.



System Level

System-level meters track the energy and water usage of specific systems within the building allowing facilities staff to see precisely how resources are being consumed. Submeters should be installed on energy and/or water-intensive systems including heating, ventilation and air conditioning (HVAC), plug loads and irrigation. While lighting consumes a large percentage of your building's energy, metering it may be unnecessary, since lighting-related electricity consumption can be determined by analyzing use schedules; however, complex lighting systems may be difficult to parse and thus require submetering. In markets where sewer rates are high, substantial savings can be gained by metering cooling tower make-up/blowdown and by submetering irrigation systems.

An additional benefit provided by system-level submeters is facilities staff can quickly identify system failures and make data-driven decisions about energy and water improvements. System-level metering is more costly than simple building-level metering, but this barrier can be mitigated by grouping together multiple system circuits into a single electric meter. While system-level meters provide finer granularity of energy and water consumption, these system-level meters produce much more data, which requires greater management to transform data into useful information. Make sure that your data management staff are equipped to handle the project.

> "Submetering has helped to identify leaks and technical issues with water and electric systems before they became an issue. For example, large spikes in interval submetering data led the facilities manager to inspect the cooling tower and discover open valves, an issue that may have otherwise gone unnoticed. With the submetering technology, they were able to identify and correct the problem before it accrued unnecessary costs."
>
> *Art Frazier, Director of Facilities Management and Services, Spelman College.*

Roles and Responsibilities

"Given the variety of utilities on campus, meter purchasing, installation, maintenance, calibration and reading is a collaborative effort between a number of internal and external stakeholders" (*Fuente, 2007*). The designation of workflow should follow a top-down approach starting with facilities management leadership and extending to external maintenance and calibration contractors, communications specialists and building occupants. In addition, campuses will often have sustainability staff and committees that want to utilize data collected from submetering and should have input on submetering design. Below is a list of key roles critical to a successful submetering program:

- **System Design** – Design with the end in mind certainly applies to metering systems. How the data will be captured, stored, reported and used impacts the design, selection, installation and maintenance of the system.
- **Installation** – Installing an individual meter should only take one or two days to complete. However, an error during the installation phase could result in significant future complications.
- **Data Analysis** – Although the data transfer process should be mostly automated there is still a significant workload associated with analysis, tracking and reporting.
- **Calibrations and Maintenance** – Consult your building controls company to learn about submeter maintenance and calibration contracts necessary to ensure meter accuracy.
- **Communications, Visibility and Reporting** – Communicating metered data to building occupants in simple language is a powerful tool for encouraging occupant behavioral change.
- **Planning** - Before beginning any work make sure to understand and identify the tasks necessary to achieve the goals for submetering.
- **Fundraising** – From utilities rebates to alumni donor programs to green revolving funds there are many ways to underwrite the expenses associated with submetering activities. Understand how revenue will be generated and sustained.

Calibration and Maintenance

Calibration and maintenance schedules will vary depending on the number of meters and technology in place. Meters should be inspected every few months to check for obvious problems such as leaks or damaged connections. Follow the calibration scheduled specified by your product manufacturer. The typical maintenance and calibration schedules is as follows:

- **Electricity** - Requires the least maintenance of all metering technologies, provided that the meters were designed for the environmental conditions. Meters should be periodically checked to ensure electrical connections are remaining stable.
- **Water** (Potable and Sewer) – Requires limited maintenance. Monthly inspections should be carried out to check for leaks, loud internal sounds and filter obstructions. Calibrations should occur annually.
- **Chilled Water** – Follows the same maintenance requirements for water.
- **Natural Gas** – Requires limited maintenance. Checking for leaks and noisy operations is generally not necessary during monthly inspections. Calibrations should occur annually.
- **Steam** - Can require significant maintenance. Monthly inspections should be carried out to ensure all connections are maintained and no leaks are present. Calibrations should occur annually.

Calibrating your meters is relatively inexpensive and essential to preventing false readings. Submetering companies will typically offer maintenance and calibration contracts designed to ensure your meters are operating correctly. For more information about calibration and maintenance, refer to ENERGY STAR®'s Metering Best Practices Guide.

Integrating Meters with Energy Information Systems

"The value of a metering program lies in communicating data so that action can be taken" (*Parker, et al. 2015*). Energy Information Systems (EIS) make up the software, data acquisition hardware and communication systems used to gather, store, analyze and display building energy usage data. EIS help to automate the data transfer, analysis and reporting processes, which greatly alleviates the staff workload. It is recommended that EIS be implemented prior to receiving any metered data to minimize future complications and prevent any back-logging.

Properties equipped with a Building Automation System (BAS), can directly integrate submetering devices with the BAS using building automation protocols, such as BACnet or Modbus. Directly integrating submetering devices with BAS software is relatively inexpensive and adding additional meters will add incremental BAS costs . By integrating the submetered data with the BAS, facility managers will be able to view interval data in a centralized platform, track and record energy use and identify consumption anomalies and operational changes.

Although direct integration of submetering devices with BAS software is feasible and may be cost-effective, it is not an optimally designed information system architecture. Information systems should be modular in design such that unrelated components of the system are separated into well-defined layers, according to the principle of *separation of concerns*. Intermingling building automation concerns with building performance tracking concerns will inevitably result in a more complex system that is more likely to fail and one that is more difficult to maintain.

Tracking Energy Progress through ENERGY STAR Portfolio Manager

An important benefit of submetering is it enables buildings to be benchmarked and compared to national averages for similar buildings allowing buildings with abnormally high energy consumption to be identified. Benchmarking can be done using EPA's ENERGY STAR Portfolio Manager, which provides an index of average energy usage for over 80 building types for comparison. Portfolio Manager also tracks the energy savings that result from efficiency projects such as building upgrades and operations improvements by comparing post-implementation energy data with pre-implementation (baseline) data. For more information about benchmarking energy consumption, refer to the companion document *Campus Benchmarking Guide*.

Communicating Submetered Data

Data gathered with submeters can serve to educate students and staff about the role they play in energy consumption. Increasing visibility of energy data can drive positive behavioral change to reduce energy consumption. An effective method of communicating energy data to building occupants is through the use of building energy dashboards, which display real-time energy data using easy-to-understand data graphics. Building energy dashboards allow energy reduction competitions between residence halls and/or academic buildings fostering collaboration and driving awareness while reducing energy consumption.

Emory University - Competing for Change

Every October Emory wages a campus-wide energy reduction competition which pins buildings against each other for three different campus categories: residential, research and administrative/classroom. Buildings from each category with the greatest reduction in energy consumption compared to the previous October are each awarded $1,000 to be used for sustainability related purchases. Emory uses social media to engage students and allow participants to share ideas about reducing energy consumption.

Campus Metering Case Studies

Every campus will face unique challenges when integrating submetering into their energy management strategy. These challenges range from funding shortages to insufficient data tracking capabilities. Thus, each campus will have to develop unique strategies to overcome these barriers. The following five campuses: Spelman College, Georgia Tech, Georgia Tech Research Institute, Emory University and Agnes Scott College successfully installed submetering systems to varying degrees of acuity on their campus buildings and many of them have run into issues that required adaptive solutions. Although the initial motivations for implementing submeters vary from campus to campus, each has greatly benefited from the increased visibility of energy and water consumption. These case studies are intended to offer perspectives on the obstacles faced by many institutions when developing submetering strategies, as well as demonstrate metering and sustainability best practice.

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Spelman College – Atlanta, Georgia

Introduction

Spelman College is a private women's institution with 2,050 students, located in Atlanta, Georgia. For years sustainability initiatives have been interwoven into Spelman's core strategic plan. Concerns for both building and occupant well-being have been driving forces in the implementation of different energy management systems.

What you need to know

- Six out of twenty-five buildings (29% of campus area) are submetered for electricity and water.
- Submetering has helped with the early identification of building system problems contributing to wasted energy and water. Case in point, large spikes in interval submetering data over a school holiday led the facilities manager to inspect the cooling tower and discover valves which had malfunctioned, a problem that may have otherwise gone unnoticed. With the submetering technology, they were able to identify and correct the problem before it accrued unnecessary costs.
- A service contract with Siemens Building Technologies allows for 24/7 HVAC controls and maintenance support. Siemens staffs a controls representative and a maintenance representative on the Spelman campus every day.

- Facilities staff installed WaterSignal Technology in the Albro-Falconer-Manley Science Center, allowing them to receive instant water consumption data along with leak/spike alerts.
- Spelman finds the submetering technology valuable and they are continuing to add electric and chilled water meters at their Camille Cosby Academic Center.

Major Takeaways

With every implementation of new technology there are bumps in the road. Spelman's main challenge is having the staff resources to analyze the submetering data they are receiving. Next steps for Spelman in their sustainability journey are to increase the submetering infrastructure in more buildings on campus and continue monitoring the data through their BAS system and EnergyDirect.com, an online reporting tool available to Georgia Power customers.

O. Lamar Allen Sustainable Education Building

Georgia Institute of Technology – Atlanta, Georgia

O. Lamar Allen Sustainable Education Building

Introduction

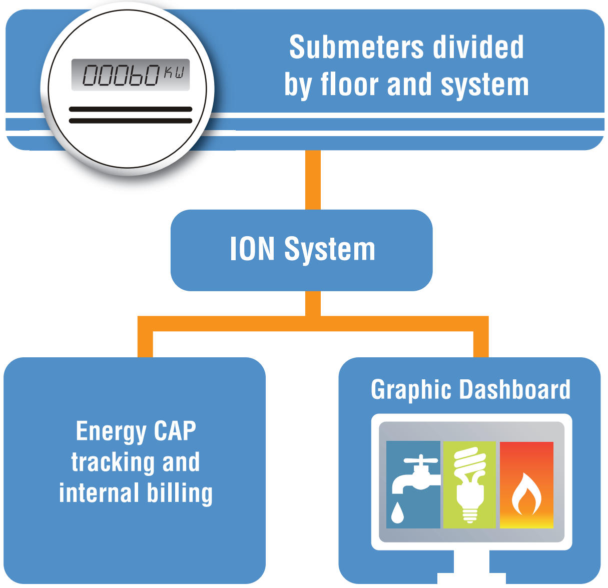
As a public research institution with over 25,000 students, Georgia Tech has made a significant effort to submeter their buildings. The initial motivation to install submeters on all campus buildings was to bill individual departments for their utility use. However, submeters were later used to find significant opportunities for energy and water conservation, especially in the O. Lamar Allen Sustainable Education Building (SEB).

The SEB is a three-story building that houses classrooms, office space and a data center. Twelve years ago, Georgia Tech had only a few electric meters for the majority of buildings on campus. Now, in one building alone, they have twenty system-level electrical submeters.

What you need to know

- Submeters in the SEB are designated by floor and monitor the energy usage of various systems including lighting, plug-loads and HVAC systems. Server rooms and elevators are submetered separately. The submetering design allows facilities staff to have an accurate understanding of how much electricity and water is being used by space-type rather than relying on industry averages.
- Metering devices in SEB are attached to a wireless network and automatically sent to Georgia Tech's storage server, the Ion System. System-level data from the Ion System is displayed on a dashboard allowing facilities engineers to view information about the building's energy end-usage and allowing operators to analyze the granular data behind the dashboard.

- Georgia Tech also uses **EnergyCAP**, a consumption interface that receives data from the Ion System. This tool is used to track energy by specifying consumption and billing. The EnergyCAP system generates an internal bill which allows Georgia Tech to accurately track and allocate utility costs across campus.
- The Facilities Management department is engaging Georgia Tech's own Aerospace Systems Design Laboratory research team to help create a functional tool to manage the raw data generated by the submeters. This tool will also contribute towards a user friendly graphical user interface planned to be available for use by executive managers, students and the operations and maintenance team.
- Georgia Tech is going a step further by engaging students and offering curriculum that teaches energy analysis and how to perform energy models, based on the real-world utility data tracked by Facilities Management.



Major Takeaways

At times it may seem that both the Ion and EnergyCAP systems are bringing in too much raw data, but the implementation of this technology allows Georgia Tech to accurately allocate utility costs for the campus. It also is allowing facilities to see the building's energy consumption in both interval and monthly values. In addition to raising departmental consumption awareness, submetering is allowing Georgia Tech to identify potential energy reduction projects and validate savings estimates.

Centennial Research Building

Georgia Tech Research Institute – Centennial Research Building

Introduction

Georgia Tech Research Institute (GTRI) is a non-profit arm of Georgia Tech whose mission is to solve complex problems through innovation, research and education. GTRI acts as a research arm for the Georgia Institute of Technology, but management of the GTRI building portfolio is completely separate from the university. GTRI's building portfolio covers one million square feet with properties located in downtown Atlanta and outside of the city in Cobb County, Georgia. Facility types range from labs to offices and event spaces.

What you need to know

- GTRI has ten electricity, three steam and three chilled water meters in their buildings.
- GTRI buildings were allocated utility costs previously based on square footage but switched to consumption billing using submeter data. The switch was the catalyst that engaged GTRI to implement energy conservation measures—in one year they saved close to $150,000.
- To assist with facility management, GTRI staff, in collaboration with Georgia Tech mechanical and electrical engineering students, developed their own dashboard with a graphical user interface for monitoring building energy use. Different than Georgia Tech's main interface, this cost-effective dashboard works in tandem with the building automation system (BAS) to display submeter data.

- GTRI's qualified staff working with students are able to gather all data in-house. This reduces implementation costs and also allows students to get real world experience.
- Staff and students use the dashboard to analyze building performance.
- GTRI's facility operators have set up alarms on air handlers to alert maintenance staff to problems as they occur.

Major Takeaways

The decision to submeter was not only a sustainable one but also a business strategy. GTRI has created an educational, hands-on experience for their students and staff while saving money on utility costs.

Evans Hall and Few Hall - LEED Gold

Emory University —Atlanta, Georgia

Introduction

Emory University is a private institution with close to 15,000 students located in Atlanta, Georgia. Emory committed to sustainability initiatives envisioned in the school's 2005-2015 Strategic Plan. Since 2005 Emory has completed rigorous projects to reduce energy use by 25% by 2015. Emory achieved the 25% energy reduction goal ahead of schedule and recently set a new goal to reduce energy by 50% per square foot by 2025.

What you need to know

- Close to 95% of buildings on campus are submetered, with one to five submeters per building. Utilities metered include water, gas, electric, chilled water and steam from the campus' central plants.
- The university has three chilled water plants supplying 51 buildings with chilled water submetered to track use.
- Emory manages an internal "Utility Company" that invoices campus departments for their monthly energy and water use which helps provide transparency of data to the campus.
- The meter information Emory receives, along with that from their Building Automation System (BAS), has given Facilities Management the ability to manage building systems and operations. Looking at energy usage data allows them to compare current consumption with previous days or months to see if consumption has changed or whether there is a system that needs to be addressed.

- Emory's Sustainable Performance Program (SPP), a continuous commissioning initiative, is a key energy saving program for Emory. The program studies factors causing performance degradation of HVAC systems leading to increased energy consumption and on-going commissioning practices to maintain high-performing buildings. Emory uses submeter data to validate actual energy savings due to the SPP and a successful re-commissioning program.
- Emory is currently collaborating with other schools across the nation through various working groups to learn best practices for sustainability and efficiency of campus facilities and operations. They are constantly finding new methods to measure and monitor their energy consumption.
- Emory currently uses ENERGY STAR Portfolio Manager as well as a dashboard system to share with the public its water and energy usage for certain buildings and Emory campuses. Emory's transparency with their consumption data allows students and staff to take accountability for their energy and water use.
- Emory has put forth many efforts to engage students as a community to participate in reaching sustainability goals. Each October the university hosts campus-wide energy reduction competitions—students and faculty all take part to compete to use the least amount of energy in residence halls and other campus buildings.

Major Takeaways

Submetering data is vital to supporting Emory's ability to manage building operations and performance. The energy and water use metrics derived from submetering are key to engaging the Emory community, including students, faculty and staff, in initiatives to support campus resource use reduction.

Campbell Hall - LEED Gold

Agnes Scott College —Decatur, Georgia

Introduction

Agnes Scott is a women's liberal arts college located in Decatur, Georgia, with an enrollment close to 1,000 students. In 2007, after signing the American College and University Presidents Climate Commitment (ACUPCC), Agnes Scott began implementing plans to reduce energy and water use on campus. All efforts to reduce the consumption of these resources are managed by a team including staff from: facilities, business, accounting and the Center for Sustainability.

What you need to know:

- Agnes Scott uses a combination of solutions to analyze and report electricity submeter data on campus. The Automated Logic Controls (ALC) system is used as the building automation system and the building control system. The ALC system tracks electricity in 17 of its 30 campus buildings. In addition, the College tracks 11 electric utility meters using Energy Direct, an online reporting tool available to Georgia Power customers. The utility meters include one main meter for the majority of campus buildings and 10 meters serving two or more buildings and outdoor lighting (i.e., parking lots). Natural gas is tracked in 29 buildings using the gas utility provider's meters.
- The college is limited in their ability to track water use per building due to utility meters serving multiple facilities. Smaller buildings, including residential buildings that now serve as offices or shared student housing are individually metered.

- Recorded data is used by the part-time energy manager consultant, facilities and the Center for Sustainability staff to track building performance compared to baseline benchmark years. The data is analyzed and reported using Metrix 4 Accounting Utility Software. Agnes Scott is also benchmarking in ENERGY STAR Portfolio Manager using data exported quarterly from Metrix 4.
- The college's Green Revolving Fund (GRF) had sparked the need for more attention to submetering and tracking options. Thus far, the GRF decisions and payback are managed based on projected savings. The college will soon be documenting actual savings and analyzing the full impact of the GRF to date.

Major Takeaways

Agnes Scott made the decision early on to reduce energy and water consumption using existing systems more efficiently. Increasing the level of data available provided the college with the information needed to prioritize their reduction efforts. Now that the college has been undertaking projects for several years, it is aware of the limits of these current systems and is considering both upgrades to the ALC system and/or more submetering to have additional data. With older meters there is a higher chance of inaccurate readings. Agnes Scott's facilities department flags erroneous data to inform reporting.

With new sustainability efforts, there can always be issues with time and capacity of staff. Agnes Scott's next steps include more focus on data collection and more training on how to analyze the data and catch anomalies so they can better understand their energy and water consumption for the long term. Additional support will be provided by student sustainability interns.