



**Sustainability in Higher Education:**

**Monitoring Based Commissioning  
Ensures Energy Efficient  
Buildings**

## Executive Summary

Higher education institutions have taken a leadership position in sustainability, energy conservation and renewable energy. Colleges and universities are high profile organizations with a complex set of constituents. They function as civic, academic, and cultural leaders, shaping opinion in their communities. Students, staff, alumni, elected officials, and the general public have high expectations - a challenge in the best economic times

Expectations of facilities managers have never been higher. Dramatic measures have taken to maximize the operating efficiency of campus infrastructure. During the past decade, institutions have reduced energy consumption through lighting upgrades, weatherization initiatives, and energy audits and system controls.

Energy efficiency is seen as key to fulfilling their schools' core mission, with almost 90% of facilities managers expecting to increase or maintain energy efficiency investments. Most agree that energy efficiency is the most cost effective way to meet their energy needs while at the same time reducing greenhouse gas emissions and cutting costs.

With aging infrastructure, rising energy costs and reduced budgets, higher education is impacted as shrinking funding and valuable resources are dispersed to growing student populations. As a result, facility managers and their institutions must focus more on energy efficiency to reduce both energy and operational costs.

Continuous commissioning introduced the idea that commissioning and energy management work should be ongoing to drive greater savings. However, the volume of information, the complexity of equipment and ongoing operational demands make this difficult to do.

**Monitoring based Commissioning (MBCx)** builds off the concept of continuous commissioning, but uses automation to deal with the complexity. *MBCx combines continuous monitoring, fault detection and diagnostics and building performance dashboards based on predictive analytics to provide persistent and continuous energy savings.*

This paper examines the issues facing higher education and how Monitoring Based Commissioning can be used by colleges and universities to reduce energy costs, improve staff efficiency and meet their sustainability goals.

Higher education institutions have taken a leadership position in sustainability, energy conservation and renewable energy. Colleges and universities are high profile organizations with a complex set of constituents. They function as civic, academic, and cultural leaders, shaping opinion in their communities. Students, staff, alumni, elected officials, and the general public have high expectations which are a challenge in the best economic times. It is not surprising that **The Princeton Review** now publishes a guide to green colleges.

According to the National Center of Education Statistics (NCES), colleges and universities annually expend between \$6 billion and \$7 billion each year on energy and utilities, about three quarters of which is directed toward electricity generation, transmission, and use. Estimates from APPA, the national association representing higher education facilities officers, suggest that America's colleges and universities collectively own and manage more than 250,000 buildings and heat and cool more than five billion square feet of space on a daily basis which represents one of largest line items in any university budget.

University's buildings consume an enormous amount of energy. Harvard reports that 98% of their emissions are associated with heating and cooling of their more than seven hundred buildings. A recent article<sup>1</sup> showed that even new buildings at Emory increased energy usage by 5% per year. Thus, increasing and maintaining the energy efficiency of buildings has become a top priority.

## Sustainability Initiatives

By 2012, more than 65% of institutions already had an office of sustainability. These offices provide for coordination of the broad range of activities necessary to meet the intuitions goals. They are also very visible in communicating to the various constituencies. As Harvard's web site explains:

“The University's buildings are where we live, work, learn and conduct life-saving, groundbreaking research. They are also where we consume an enormous amount of energy—98% of Harvard's emissions are associated with heating and cooling the more than seven hundred buildings spread across campus. As the University works to meet its ambitious climate goal to reduce emissions 30% by 2016, increasing the energy efficiency of our buildings has become a top priority.”

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<sup>1</sup> “Commissioning and Emory's Sustainable Performance Program” **Facilities Manager** January/February 2015

Colleges and Universities have a long history of cooperation, especially when it comes to best practices. Higher Education has been extraordinarily active in developing projects and embracing standards in energy usage and sustainably. Some of these include:

- Buildings that adhere to advanced levels of energy-efficient performance criteria are commonplace on many college and university campuses. The US Green Building Council has seen the number of registered projects in higher education increase significantly in recent years, with nearly 300 projects that are LEED certified and 1,700 more pursuing certification as of September 2015.
- 600 institutions have signed the American College & University Presidents Climate Commitment in an effort to decrease carbon emissions while increasing the research and educational programs to help prepare future generations; 290 of these institutions have made a commitment that all new campus construction will be built to a minimum LEED Silver standard or equivalent.
- Association for the Advancement of Sustainability in Higher Education (AASHE) developed the Sustainability Tracking, Assessment & Rating System™ (STARS) program. STARS is “a transparent, self-reporting framework for colleges and universities to measure their sustainability performance.” More than 500 institutions have participated from a broad section of the higher education community. STARS provides sustainability goals for institutions along every step of their sustainability plans, from entry points of recognition for beginning schools to long-term sustainability goals. STARS allows for comparisons over time and across schools using a common framework.

## Rising Expectations

Expectations of facilities managers have never been higher. Dramatic measures have been taken to maximize the operating efficiency of campus infrastructure. During the past decade, institutions have reduced energy consumption through lighting upgrades, weatherization initiatives, and energy audits and system controls.

According to a 2015 study<sup>2</sup> conducted with higher education facility managers, energy efficiency is seen as key to fulfilling their schools' core mission, with almost 9 out of 10 respondents expecting to increase or maintain energy efficiency investments. Eighty-eight percent of respondents also agree that energy efficiency is the most cost effective way to meet their energy needs while at the same time reducing greenhouse gas emissions and cutting costs.

The biggest factor driving schools' energy efficiency efforts is cost savings, according to the same survey, with environmental benefits and industry standards rounding out the top three reasons for becoming more energy efficient. However, obstacles exist to achieving these objectives. While 92 percent of respondents stated that their school had a culture that encourages energy efficiency practices, organizational barriers are challenging their ability to achieve efficiency goals. Fifty-nine percent view this as the biggest obstacle, with insufficient funding and lack of a clear definition of success also ranking highly.

## Declining Budgets

Aging infrastructure, rising energy costs and reduced budgets are major issues affecting facilities across a multitude of industries. Higher education is especially impacted as shrinking funding and valuable resources are dispersed to growing student populations. All of these factors greatly impact facility managers and their day-to-day operations. As a result, facility managers and their institutions must focus more on energy efficiency to reduce both energy and operational costs.

According to an analysis<sup>3</sup> by the Association of Public & Land-grant Universities (APLU), budgets have grown tighter. The report looked at revenue and spending on a per-student basis at 621 public four-year institutions between 2007 and 2013. Revenue has declined due to lowering state contributions. While public universities have raised tuition rates to make up for large state funding losses, tuition hikes has not fully offset the difference.

Three-quarters of all college students attend public institutions. According to the College Board, state funding per full-time equivalent student in public institutions declined from a high of \$10,110 (in 2014 dollars) in 2000-01 to \$6,960 in 2012-13, and rose to \$7,540 in 2014-15. More than 95 percent of states in the U.S. have been spending less on their public higher education systems than they did before the Great Recession according the Pew Center.

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<sup>2</sup> "Higher Education Energy Efficiency Report" [www.ase.org](http://www.ase.org)

<sup>3</sup> "How Did Revenue and Spending per Student Change at Four-Year Colleges and Universities Between 2006-07 and 2012-13?" August 2015 at [aplu.org](http://aplu.org)

## Aging Infrastructure

A large university campus is much like a small city with a range of building types, usage and construction techniques. A key factor facing higher education institutions is aging infrastructure. In the 2015 survey, 59 percent responded that the average age of their buildings exceeds 15 years, and only one in five reporting that the average age of their building is below 10 years. As facility leaders look to upgrade existing buildings, compatibility with new technology ranks as most important when considering making an investment. Compatibility with legacy systems outranked quality of the product and technology advancements of the solution.

With the majority of today's higher education buildings expected to serve students for the next several decades, it's more important than ever for higher education facility managers to understand how to take advantage of available resources in order to effectively manage aging infrastructure. In fact, 59 percent of higher education facility managers surveyed stated that the average age of their buildings was 15 years or older. There are tremendous opportunities that exist for improving energy management in terms of software, infrastructure modifications and leveraging government programs.

Age alone is not the most critical factor. Type of construction and how the building systems are maintained are at least as important. A 2015 report<sup>4</sup> on energy use in large Boston office buildings show those built before 1950 used "significantly less" energy per square foot on average than buildings constructed after 1950. Offices buildings with the lowest energy use per square foot are a century old:

"In analyzing their reported energy data, New York and Seattle found similar patterns of EUI by building age," the report notes. "Much of this variation is due to changes over time in construction materials and building systems: pre-WWII buildings tended to use masonry construction, for example, compared to glass-curtain wall construction in the 1960s and 1970s."

An analysis by Penn State of data from the Commercial Building Energy Consumption Survey (CBECS) confirms that the oldest commercial buildings (built prior to 1920) have lower energy consumption per square foot on average than buildings built more recently. The analysis evaluated the apparent trend between building energy consumption and age, and then investigates how other variables in the CBECS survey (e.g. HVAC system type, renovation type) affect this trend. Their analysis suggests that other variables, particularly those related to the building's HVAC system, play a significant role in determining energy consumption. It is not simply the building's age, but the equipment, how it is used and maintained that most affects energy efficiency.

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<sup>4</sup> "Energy and Water Use in Boston's Large Buildings," August 2015 Greenovate Boston

## Commissioning Matters

Given a college or university's diverse inventory of buildings combined with complex use patterns, it is not surprising that controlling energy costs are extraordinarily challenging. Facilities managers recognize that wasted energy increases over time. Buildings experience degradation caused by malfunctioning equipment and changes in building occupancy. As facilities managers respond to occupant complaints and perform routine maintenance, systems stray from how they were designed. This results in lower building efficiency that gets compounded over time.

In response to this trend, facilities managers will periodically return to the concept of commissioning. **Recommissioning** or **Retrocommissioning** optimizes the mechanical or electrical systems in an existing building to tune the building's systems to new set points based on its actual operations. According to a study by Navigant<sup>5</sup>, recommissioning is performed at most every three to 5 years and more typically once every 5–10 years. This is understandable because the process can be expensive. However, retrocommissioning can reduce a building's energy consumption by up to 10%–20% in particularly out-of-tune buildings, though a majority of buildings can achieve savings in the 5%–10%.

There are numerous examples of how well this has generated savings in higher education:

- “At Harvard Business School, an ongoing commissioning project underway since 2008 has covered 14 buildings, yielding more than \$320,000 in savings that have contributed to a 3.6 percent reduction in greenhouse gas emissions. The simple payback (when the costs are made up for by the savings) for the projects they have implemented is well under two years (1.51 years).<sup>6</sup>”
- “In addition to efficiency improvements through on-campus power generation, MIT has partnered with NSTAR to implement energy efficiency retrofits to its older buildings and mechanical equipment. MIT and NSTAR have successfully concluded the first phase of “MIT Efficiency Forward”—a groundbreaking, multi-million dollar pilot collaboration—achieving their ambitious goal to reduce 34 million kilowatt-hours between 2010 and 2012. These savings are equivalent to the electricity used by 4,500 Massachusetts homes.<sup>7</sup>”
- “The total estimated annual cost savings of the facilities under consideration would be in the neighborhood of \$1 million, and provide a revised total annual utility cost of \$4.58 million. A 5 percent annual degradation of this cost is \$229,000 in the first year. This

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<sup>5</sup> “Building Optimization and Commissioning Services” Navigant Research Q1 2015

<sup>6</sup> <http://green.harvard.edu/topics/green-buildings>

<sup>7</sup> <https://sustainability.mit.edu/sustainability-today/campus-systems>

would result in the cost of the FTE having an annual payback of approximately six months.<sup>8</sup>”

The concept of **continuous commissioning**, first developed by the Energy Systems Laboratory at Texas A&M University, introduced the idea that the analysis and remediation of problems should be ongoing. Thus, the building owner benefits from more manageable ongoing investments that yield saving much sooner which also eliminates the compounding of costly energy waste over time.

While the concept of continuous commissioning is appealing, it can be very challenging to implement. First, facility managers need to devote time and resources to the process, resources that are responding to ongoing operational needs and issues. Second, the amount of information from building management systems, devices under management and their subsystem components can be staggering with a massive number of control points to consider.

Automation is the logical approach to dealing with these issues. **Monitoring based Commissioning (MBCx)** builds off the concept of continuous commissioning, but uses automation to deal with the complexity and volume of information. *MBCx combines continuous monitoring, fault detection and diagnostics and building performance dashboards based on predictive analytics to provide persistent and continuous energy savings.*

## Reduced Energy Costs

Reduced operating expenses are perhaps the most important benefit associated with commissioning, particularly for retrocommissioning of existing buildings. As we have seen, building owners can expect 5%–10% reduction in energy costs through retrocommissioning, though some poorly performing buildings have enjoyed even greater levels of energy efficiency.

MBCx allows you to realize these savings much sooner – in months rather than years. In a study<sup>9</sup> done by Lawrence Berkeley National Laboratory, the authors benchmarked a portfolio of MBCx energy savings for 24 buildings located throughout the University of California and California State University systems:

“A total of 1120 deficiency-intervention combinations were identified in the course of commissioning the projects described in this report...From these interventions flowed significant and highly cost-effective energy savings. For the MBCx cohort, source energy savings of 22 kBtu/sf-year (10%) were achieved, with a range of 2% to 25%.

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<sup>8</sup> “Commissioning and Emory’s Sustainably Performance Program” Facilities Manager, Jan/Feb 2015

<sup>9</sup> “Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects” by Evan Mills, Ph.D and Paul Mathew, Ph.D, Lawrence Berkeley National Laboratory June 2009

Median electricity savings were 1.9 kWh/sf-year (9%), with a range of 1% to 17%. Peak electrical demand savings were 0.2 W/sf-year (4%), with a range of 3% to 11%.

Median energy cost savings were \$0.25/sf-year, for a median simple payback time of 2.5 years... Energy savings are expected to be more robust and persistent for MBCx projects than for conventionally commissioned ones.”

Clearly there are significant energy savings for most buildings and MBCx allows facilities managers to realize them sooner and benefit from them for a longer period of time.

## Improved Staff Effectiveness

University facility managers must deal with a wide range of buildings with different mechanical systems, controls and building automation systems. This makes it difficult to get a complete view of the issues affecting energy usage on a campus. Monitoring based Commissioning systems provide an integration point across all of these assets. Thus, an MBCx system serves as the one common source of the truth for everyone. A secure cloud based implementation can reduce the IT overhead costs while making access from mobile devices much easier. This gives staff the information they need when they need it. Role based access control allows the facilities manager to determine who should see what information.

Currently, many building maintenance teams react ad hoc to disruptions in building performance, thereby missing many opportunities to realize latent energy efficiency potential or optimize occupant comfort, one of the other key benefits of commissioning. Predictive analytics combined with features like fleet comparisons help managers identify problem areas. While traditional commissioning identifies improperly operating equipment, monitoring-based commissioning has the ability to identify future problems in equipment before they become disruptive. Through the continuous tracking of energy consumption and equipment operation, faults can be detected and maintenance can be performed.

## Support Your School's Green Initiatives

LEED certification, which includes a commissioning process, allows building owners to take advantage of a growing number of state and local government incentives. An MBCx system can help your building achieve points in LEED v4. LEED also has significant benefits in complying with regulations. For example, buildings are exempted from the NY Local Law 87 requirement for energy audits if they have achieved EPA Energy Star label or U.S. Green Building Council LEED certification for at least two of the three years preceding the filing date.

### Summary

- **Hard dollar cost savings** in the form of **reduced operating expenses** by eliminating wasted energy improves building efficiency 5%–20%. MBCx allows you to realize these savings in months rather than years.
- MBCx helps **staff become more efficient and proactive** in building energy efficiency. A continuous monitoring system gives you this **visibility into the data your staff needs when they need it** and the analytics in MBCx make it much easier to maintain peak performance of these assets. **Fault Detection and Diagnostics (FDD)** identify future problems in equipment before they become disruptive.
- MBCx can help you better meet your school's commitments to **sustainability and green initiatives**. MBCx can play an important role in helping meet your energy efficiency benchmarks and getting points for programs like LEED certification.

## ABOUT FACILITYCONNEX POWERED BY GE

**Powered by GE Proficy software** and the Industrial Internet, FacilityConneX is an Enterprise-level intelligent monitoring and knowledge action system designed to bring smart asset monitoring, advanced predictive intelligence, continuous management and energy savings; all available in a secure hosted Cloud environment with online and mobile visibility.

With a cloud based solution you get the lowest TCO (total cost of ownership) while never losing visibility into conditions that matter. Our continuous smart monitoring system – FacilityConneX - provides complete insight into the condition of your equipment in real time. You will get alerted when things are not running at optimal performance levels, and know exactly what needs to be done to resolve the problem quickly. FCX watches not only mechanical fault detection scenarios, but resulting system cost issues as well.

FacilityConneX connects all of your disperse systems and hidden pieces of equipment to give you complete visibility. Remember the number of subsystems of an air handling unit? FacilityConneX does 1000s of checks continuously with advanced fault detection techniques designed to optimize your equipment to the highest performance and with the greatest energy cost awareness in the market.

Our **FacilityConneX predictive analytics** will do three things for you...

- Watch your equipment and the thousands of fault detection scenarios that can go wrong.
- Classify your findings into your worst offenders to help you focus on the right priorities, at the right time.
- Correlate what is happening overall and connect the savings with the actual correction needed at the equipment level.

### FOR MORE INFORMATION VISIT:

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