Advanced Metering at University of Illinois Urbana-Champaign

Deploying Advanced Electrical Power Meters
to Reduce Energy Usage at a Growing Campus

Glossary of Terms:

Energy Conservation – The prevention of wasteful use of energy with the goal of ensuring that energy is used efficiently.

Facilities and Services Department – A department within a university, whose role is to ensure that the university buildings meet the needs of the people using them, while also running efficiently.

Retro-commissioning – The process of evaluating the performance and usage trends of a building, and then improving upon the current state of the building in order to save energy.

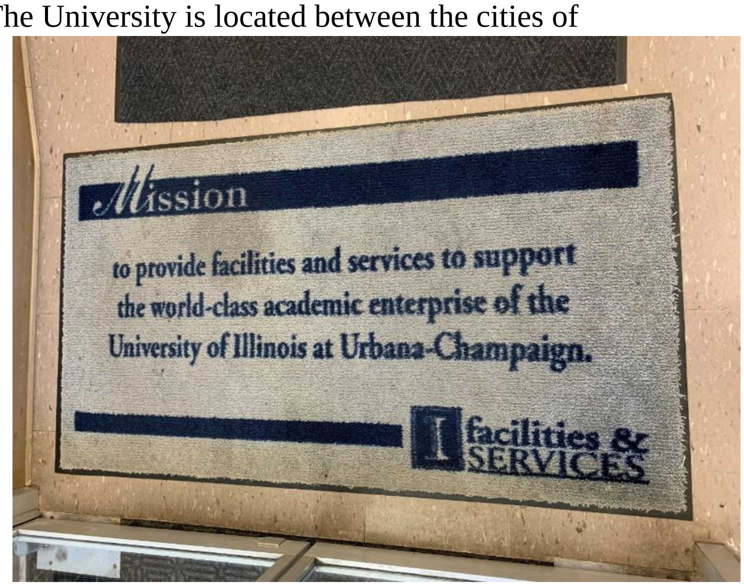
Optimal State Curve – A graph used to visually depict the energy optimization process, showing that the process is within budget and additionally saves the university money.

Operational Budget – The amount of money a university department is given annually for its expenses.

Power Metering – The best way to measure the power quality and energy usage of a business or building.

Introduction – About UIUC

The University of Illinois Urbana-Champaign, also known as UIUC, is a public university located in Champaign County, Illinois. The University was founded in 1867, making it the oldest campus in the University of Illinois system. It is also the largest campus in the University of Illinois system. UIUC is a prestigious, world-renowned research school, with an R1 Doctoral Research University classification, which signifies the highest level of this activity for a college. This makes the school a great option for engineering and computer science majors. In addition to its popular research programs, UIUC is also known for its tremendous teaching programs and its public engagement. UIUC incorporates a range of departments and majors, with 18 different colleges and schools within it. It has hundreds of buildings throughout its campus, including dormitories, football stadiums, and classrooms. The University is located between the cities of Urbana and Champaign and is one of the major highlights of the area, the location being commonly considered a college town. One of the departments within UIUC is the Facilities & Services Department. Utility Distribution, a department within F&S, is managed by Robbie Bauer, who implemented EIG meters in order to analyze the re-commissioning process of buildings throughout the University, resulting in saving UIUC millions of dollars during and after the "Great Recession of 2008."



The Great Recession of 2008

When the great recession of 2008 occurred, every major American company was impacted, and even distinguished and noteworthy universities like UIUC took a hit. As the economy began to spiral downward, funds were cut back and every corporation, big and small, was re-evaluating its financial strategies in order to cut costs and save money. As a state school, UIUC received 50% funding from the State of Illinois prior to the 2008 financial crisis. After 2008, that number was drastically reduced to only 33%. The University needed to find ways to save money and overcome the financial hurdles thrown at it by the great recession. The University's goal was to save money while keeping the jobs of their employees and continuing their legacy as an affordable and reputable university.

Path to Power Metering

In 2008, the Facilities & Services department at UIUC was tasked with the difficult job of finding ways to save the University money during the recession. At the same time, the University wanted to instill a culture of energy conservation among its staff and students. This was a challenging task for the entire University. However, F&S, along with Robbie‘s team, assessed the situation and determined that cutting energy costs would be the best way to help the University financially, in both the short and long term. This would also implement a culture of energy preservation to help the environment and its people.

One idea that stood out to the Facilities department was the process of retro-commissioning buildings on campus to make them run more efficiently. While the exact benefits of retro-commissioning were still unknown, it was clear that it would help save the University money, and at the very least would have a positive impact for a couple of years, if not more. At this time, the industry belief was that a building that was retro-commissioned would remain efficient for seven years. After investigating the benefits of retro-commissioning, the Facilities department realized they could potentially save the University millions of dollars over the next few years. They were eager to begin the optimization process of the buildings on campus; however, there were obstacles to overcome before implementing the retro-commissioning project could become a reality. Still, in the midst of the financial crisis, winning the support of other departments on campus would not come easily. To demonstrate that there was not only validity, but also necessity, in taking these steps, Robbie needed to have solid, concrete data to back up his claim. He would need measurable proof that retro-commissioning the buildings would be a great financial investment, at a time when the world was struggling financially.

The Facilities department recalled its investigation into power metering as a result of previously attended energy conferences and decided to revisit this topic. The personnel knew from past experience that metering was an optimal way to get concise data that would legitimize their claims that retro-commissioning the buildings on campus would be extremely beneficial. The Facilities department saw this as the first step towards getting the buildings on campus to an optimized level. At the same time, Robbie still wanted to implement a cultural shift that involved making energy conservation a priority. The use of metering would not only give Robbie access to great data, but it would also create energy conservation practices and help building occupants understand how much money they spent on operating costs. To the Facilities department, it seemed like a win-win scenario on all counts. The next question was finding a power meter that would be able to do everything necessary to tackle the optimization process and earn the support of all the building “owners” on campus.

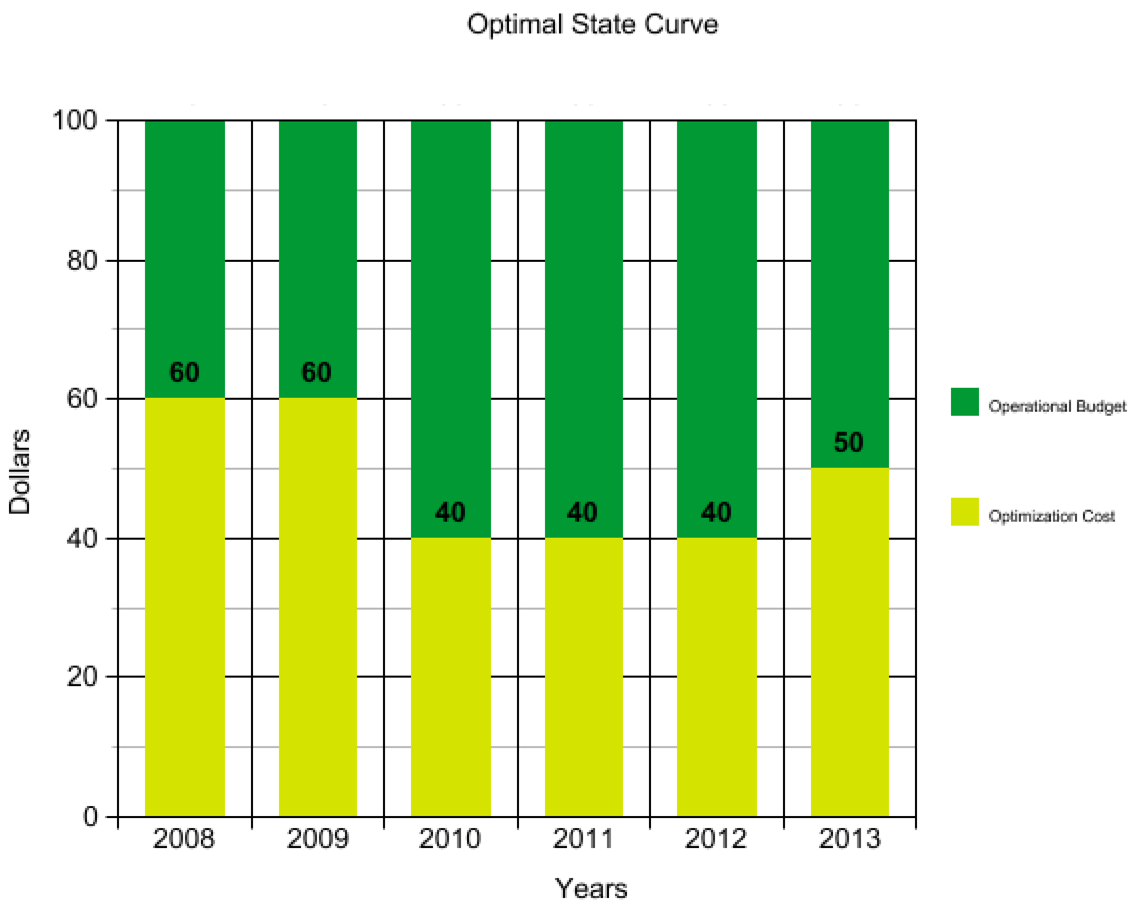
The electrical power metering systems that were in place were outdated, like most University’s systems at the time. Unfortunately, this resulted in inconsistent billing of the various departments on campus and no clear data to establish a baseline for the amount of energy consumed. The search began for a power metering vendor who could offer more dependable data. Finding the perfect meter to meet the needs would be all about reliability and accuracy. Testing for accuracy and verifying the meter would work consistently, with real time settings, were only part of the many features explored when deciding which power meter to go with. Other important features included communication capabilities, in order to eliminate manual reads, and having waveform capture capabilities, to track power quality events. Overall, the new meters would need to:

- Be highly accurate
- Be testable for accuracy
- Have communication capability in order to eliminate manual reads
- Have waveform capture capability in order to track power quality events
- Have simple data integration
- Be easily installable

After much research, Robbie decided to go with EIG's Nexus® 1272 advanced power quality meter. The meter had all the main features Robbie was looking for in order to justify his costs, and more. In addition to the meter being a great fit, Robbie formed a relationship with EIG and grew to trust them and the safety and efficacy of their products. This sense of confidence came not only from the meter and its high accuracy levels, but from the working relationship forged between Robbie/UIUC and EIG during the buying process, which continued during aftersales care and technical support assistance.

Discovery of the Optimal State Curve

As the oldest state university in Illinois, it was not surprising that many of the UIUC buildings were less energy efficient as the University would like, which in many cases led to undesirably high energy usage. In 2008, before the use of power monitoring, the University was not trending real time electrical data and as a result, each building's energy usage was known only on a per month basis. The University needed to rely on a small team of employees who performed manual readings to the best of their ability, without a baseline or smart technology. With a small building automation team of only three members and one manager, there were difficulties both in optimizing the buildings' energy use and in gathering the necessary data to bill appropriately. The small size of the team, combined with the large number of buildings, resulted in limited manpower. This created an inability to deploy building optimization. Instead, the team had just enough members to keep the buildings commissioned and working. To get the buildings to an optimized state and instill a culture of energy preservation, Robbie began researching the optimal state curve. The optimal state curve, when implemented, shows positive results almost immediately. Below is a graph of how the curve works with fabricated numbers, for simplification.



**Numbers used are for simplicity and do not reflect any of the actual numbers used or spent by UIUC.*

In the example chart, the green bar is a fabricated representation of the operational budget for the Facilities department. An operational budget typically does not change over time, since it is a set amount of money which the department needs to spend in order to keep its operations running. In this case, the operational budget set in the first year, 2008, was $100,000, which remained constant throughout the next six years.

The yellow bar represents the optimization cost, which is the cost to optimize the buildings. In the first year, it took $60,000 of the $100,000 budget to optimize the buildings. For the optimal state curve strategy to take effect, the University would initially have to borrow money from the next year's budget since they were limited to using $100,000 in their first year. This borrowed money would be spent in 2008 but would be covered under 2009's expenses. This way the University managed to stay under their budget, while also getting the buildings to the most optimized state possible.

No savings would be seen in 2009, since 2009's budget was used to pay for the building's optimization in 2008. Instead, 2009 would be considered a break-even point for the University. The real savings would be noticed in the following years. Now that the buildings were at an optimized state, in 2010, 2011 and 2012, the cost to keep the buildings optimized would go down. In this example, the number dropped from $60,000 per year to only $40,000. Actual savings can be even more extreme.

The cost to keep the buildings optimized would remain at $40,000 per year for about the next three years. During that time, the University would now have an extra $20,000 per year in their budget that they could spend elsewhere. This extra savings could be used for other projects, such as an energy recovery wheel, or increasing the number of team members within the department to increase manpower and ensure smooth operations.

In the sixth year, the cost to keep the buildings optimized would go up slightly. This is because as time goes on, the buildings will begin to fall out of their optimized state, and it will take a bit more spending to get the buildings back to normal. In this example, the cost in year six is $50,000 to keep the building optimized, which is $10,000 more than the previous three years' maintenance costs. It is still less than what the cost would have been if the buildings had never been optimized at all, and there would have been no additional savings in that case, either. By year seven, the optimization cost would fall back down to $40,000 and stay there for the next three years, beginning the cycle once again. However, the optimization costs would never go back to the original cost of $60,000.

A quick breakdown is shown below:

2008 = $60,000 optimization cost + $60,000 optimization from 2009 budget, spent in 2008

2009 = $60,000 already spent in 2008

2010 = $40,000 spent on optimization cost, resulting in $20,000 savings

2011 = $40,000 spent on optimization cost, resulting in $20,000 savings

2012 = $40,000 spent on optimization cost, resulting in $20,000 savings

2013 = $50,000 spent on optimization cost as the buildings begin to fall out of the most optimized state, but are still close to being optimized

2014, 2015, 2016 = $40,000 spent on optimization cost, resulting in $20,000 savings

Retro-Commissioning

After partnering with EIG and experiencing a smooth and cost-effective transition to the use of the Nexus® 1272 meters in University buildings, other departments were able to see real data and understand why retro-commissioning needed to happen. Thanks to metering, the University was now able to track each building's energy use by square footage. This equipped them with the information of which buildings on campus had the worst energy usage relative to their size and energy needs. With the acquired data garnering the backing of fellow departments, it was now time to begin the retro-commissioning process. This was an exciting development, as retro-commissioning would allow the University departments' employees to work together collectively as a unit, instead of each department looking at their own sections. It made the whole process much more efficient and created an unparalleled level of coordination. It also acted to elevate the cultural shift to energy conservation on campus, as different departments were interacting with each other more often.

The first step in the retro-commissioning process was the evaluation of the energy control process. The retro-commissioning team needed to look at performance, appropriate trending data, and the length of recovery time after a building was turned back on after being shut off. This analysis began at the air handling unit level and then worked its way out to the rooms. The retro-commissioning team started by looking for anything that was running continuously, 24/7, in the buildings, based on the metering data that they received. They then determined whether they could reduce that usage. A few machines needed to be running all the time, but many were being overused. For example, the team realized certain areas were empty during certain hours, so they could turn the lights off in unoccupied buildings. Another finding was that some buildings would be empty except for one person. As a prestige research school, it wasn't uncommon for limited employees' lab work to require the entire building to be energized. With this information, a compromise solution could be found to better optimize the energy needed by the research labs to get the work done with the necessary equipment and to also preserve energy usage as much as possible.

The next step was to find any additional places that energy usage could be reduced. It was important to start with whatever would bring in the quickest return on investment. This way, the team would be saving money faster, so they could re-invest that saved money to make more changes, in return saving even more money and continuing to stay under budget. Next, the team looked for anything that was broken and needed to be fixed in the buildings, such as reheat valves, sensors, and discharge air temperatures. Fixing all these things would help the buildings run in an optimized state. After that, they would take a deeper look into the technology being used in the buildings. By evaluating the technology, the retro-commissioning team would be able to decide if they should make improvements to make the technology more efficient, retire it completely, or keep their processes the same. As a rule of thumb, outdated machinery would need to be retired completely and replaced with more up to date technology, while more recent technology could either be improved on to be made more efficient or left alone. For example, items such as fans usually required enhancements over time and more efficient technology to be used as it became available. Meanwhile, certain controls were retired in an effort to go digital, and were replaced with significant units of DDC, Direct Digital Control.

Results

As a result of retro-commissioning, departments spent less money on their operating expenses as the buildings were now running in an optimized state. The Nexus® 1272 meters were able to show that buildings do, in fact, fall out of the optimized state after about 3-5 years. This was less than the industry believed at the time, but EIG meters were able to provide energy data that showed the actual amount of time a building would stay optimized, setting a new industry standard. The reduction in annual energy consumption expenses, as shown in the optimal curve graph, saved the University millions of dollars on reduced energy costs, while also allowing the departments to continue to grow and thrive. Not only were there savings in the department's budget, but the optimization of buildings allowed the department to save money on energy, electricity, power, and so on throughout the next 5 years. Retro-commissioning not only had a tremendously positive impact financially, it was also able to improve energy usage and conservation. Both of the initial goals the Facilities department had when the project began in 2008 were not only met but exceeded in many ways. The University was able to save money on energy costs while creating a culture of energy conversation.

The energy conservation culture created shows the improvement of UIUC over time, which exceeds most comparable universities today. One hidden benefit realized after the retro-commissioning was completed, was the cross-departmental communication and connectivity that it created. The retro-commissioning team had to be in constant contact with the occupants of the buildings throughout the entire process and even afterwards. Discussions of the best practices, economic impact, and whether it was worth it to commission an entire building for one or two people, resulted in a sense of community throughout the University. Different departments on campus were now working together to ensure optimal energy usage throughout UIUC. Dorm buildings would even host pizza parties as an incentive for students whose floor used the least amount of electricity for that month. The cultural shift in energy conservation had officially taken place, and students and faculty alike were excited to play a role.

In the present day, building occupants and managers have enough knowledge to do more with the meters than ever imagined. The data the meters provides has become a valuable asset every day. Building managers now have a high enough level of understanding, and enough access to data, to be held accountable for their energy consumption. UIUC building occupants and managers can see and understand that both the building data and meter data they are receiving is highly accurate and not questionable. The meter data was so helpful and accurate, in fact, that the energy conservation practices team grew. Robbie's team in the Facilities department more than doubled in size, growing from a team of three in 2008 to over 20 team members, and counting, in 2020.

Over the course of 10 years, F&S was able to save the University a whopping $28 million in energy costs. This equates to an approximately 38% reduction in energy consumption, with the University being on track for as high as a 50% reduction. To make matters more impressive, this energy reduction occurred while the University was growing, both in size and square footage. The money saved over the 10 years possibly prevented some increases in student tuition and avoided possible employee layoffs. It resulted in growth and employees being added to the growing energy conservation teams. Robbie himself was promoted from Integration Specialist to Utility Distribution Manager, for his efforts.

Future Plans

The University of Illinois Urbana-Champaign currently has 331 advanced EIG meters on campus. With the plethora of benefits metering has provided, they plan to continue to grow and implement more meters in the future. Since buildings on campus were built using space allocations, more buildings will need meters to monitor their energy usage in the future. Eventually, the University will have to split costs between Engineering and parking space allocations. To do so, they will begin looking at submetering, using EIG's Shark® MP200™ multi-point high-density metering system. With the entire University in support of energy conservation and having firsthand experience with the benefits of metering, continuing to grow its energy monitoring system with the assistance and partnership of EIG, is a beneficial strategy for UIUC.