Facilities & Services
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Energy Management Plan

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Prepared by Facilities & Services.

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1.0 ENERGY MANAGEMENT PLAN FRAMEWORK

The University of Illinois Urbana-Champaign (*Illinois*) community of students, scholars, and alumni is changing the world. An original land-grant university, *Illinois* pioneers innovative research, tackles global problems, and expands the human experience. Transformative learning experiences, in and out of the classroom, produce alumni who are leaders. Outstanding academic programs, award-winning faculty, extraordinary resources, and bountiful opportunities attract top-caliber students. *Illinois* has over 48,000 full-time students and over 11,000 faculty and staff. Providing safe, reliable, and efficient utility service to campus facilities is the key to successful academic instruction, research, and outreach.

This Energy Management Plan is specific to the University of Illinois at Urbana-Champaign. It is intended to address both the **Supply** side and the **Demand** side of campus energy. The *Illinois* Utilities and Energy Services (UES) Division is a part of Facilities & Services (F&S), which is the largest administrative campus unit. Facilities & Services remains a trusted partner and collaborator with the university community's efforts to attain excellence in achievement for a preeminent research university with global impact. Their service delivery reaches the entire campus community in more than 640 buildings, across 22M gross square feet, and over 4,544 acres of grounds. Annual campus energy usage is approximately 3 trillion BTUs.

The current structure of Utilities and Energy Services is based upon the structure recommended by the University President's Energy Task Force Report in 2007. The task force was created to evaluate the significant deficiencies in the university's utility and energy operations, processes, and finances at that time. They utilized energy consultant Scientific Applications International Corporation (SAIC) and other consultants to do a comprehensive evaluation and prepare a report on energy policy, management, infrastructure condition, and operations. They also evaluated outsourcing or privatizing utility operations. The Energy Task Force recommendations included moving both utility budgeting and utility operational responsibility to the campus and providing continuing investment in Energy Conservation Measures (ECMs) utilizing energy cost savings for funding. The UES Division was created at Facilities & Services in 2010 after utilities were returned to campus responsibility and integrated with the building energy system control operations and maintenance. The structure implemented along with the continuous development of specific areas and effective integration into the overall utility and energy services has proven not only to be successful, but also to provide a significant Return on Investment (ROI).

1.1 Prairieland Energy, Inc. (PEI)

The University of Illinois, through the Board of Trustees (BOT), organized Prairieland Energy, Inc. in 1996 to interface with the energy market. PEI became a "Market Participant" through the Midwest Independent Transmission System Operator in 2006 and executed a service agreement for network integration transmission service with them at that time. PEI remains a Market Participant in what is now Mid-continent Independent System Operator (MISO) allowing cost effective wholesale energy transactions for *Illinois*.

2.0 MANAGEMENT PLAN BASIS

2.1 Reliability

The infrastructure required to serve *Illinois* must be highly reliable and resilient to a variety of potential circumstances. At any given time there could be the next game changing discovery in any one of our numerous research facilities or by a student on the path to significant contribution to society. The proper space conditions must be maintained at all times in order for some of these research activities to be successful. Back-up power evaluations have included options at the building level and at the campus level.

Campus buildings have various levels of backup/redundancy depending on the age of the facility, the intended use, and the risk tolerance. Newer lab buildings, such as Micro and Nanotechnology Lab, Beckman Institute, Chemical and Life Sciences Lab, and the Institute for Genomic Biology (IGB), are each configured slightly different but in general have two separate cable feeds and transformers for redundancy as well as the ability to transfer the loads to either circuit. Our Facility Standards require emergency generators at the buildings for life safety systems and typically include backup power for priority lab and/or building equipment. It is recommended that an Uninterruptable Power Supply (UPS) be provided for equipment requiring the highest level of reliability. That said, there is always an evaluation of redundancy versus cost on proposed buildings, and they don't necessarily end up with the recommended level of reliability everywhere. For example, Beckman Institute did not have an emergency generator provided when it was constructed. A subsequent study indicated that to retrofit emergency power infrastructure to Beckman would range from ~ $2M to $10M depending on how much of the load would need back-up power. That project was not funded, and Beckman continues to lack emergency backup power.

There are many buildings with backup power needs of varying nature that would require a major funding initiative to solve them all individually. Our Combined Heat and Power (CHP) system at Abbott Power Plant (Abbott or APP) joined with an underground central distribution system is capable of operating as a "micro-grid" or in "Island Mode" if there was ever a major failure of the Regional Power Grid. The advantages of this type of infrastructure was proven at Princeton University following the catastrophic Superstorm Sandy in 2012 when their campus remained open while other facilities in the region were without power for days. Maintaining reliable fuel sources for Abbott's CHP system is a key component to maintaining reliability. We are fortunate to have diverse fuel capability including coal, fuel oil, and natural gas. We are currently upgrading our power management controls to enhance our capability to run in Island Mode if necessary. We recently installed two Black Start Generators at APP and emergency generators are provided for new buildings and major renovations where needed.

2.2 Sustainability

F&S strongly supports the *Illinois* Climate Leadership Commitments, including the Carbon Commitment to be carbon-neutral no later than 2050 and the Resilience Commitment to work with the local community to build resilience to existing and expected climate changes.

For the Resilience Commitment, the UES Division provides educational tours and presentations to local residents. This includes tours of Abbott Power Plant and the Solar Farm for groups ranging from the Girl

Scouts to state legislators to international leaders. UES also supports academic collaborations for increasing resilience to climate change by providing researchers with access to data and by participating in regional resilience efforts, such as increasing the use of green infrastructure for rainwater management.

For the Carbon Commitment, the UES Division has led the most successful efforts for carbon reduction since the first Illinois Climate Action Plan (iCAP) was signed by the Chancellor in 2010. With a proactive and continued focus on energy conservation, a demonstrated commitment to the implementation of clean energy technologies, and professional staff actively participating in ongoing research for long-term carbon solutions, UES will continue to lead *Illinois* in the shift away from fossil fuels. Campus has supplemented the significant improvements in energy efficiency and aggressive integration of renewable energy with Renewable Energy Certificates (RECs) and/or Carbon Offsets to meet intermediate goals when necessary.

This plan refers to several strategies that may assist in reduction in carbon emissions as technology develops but emphasizes the recommendation of the best current option for campus to meet its goal of Carbon Neutrality by 2050 (or earlier). This includes a concerted effort in conversion of our existing building infrastructure in three specific areas; converting steam building piping and terminal devices to low temperature hot water heating, upgrading obsolete control systems to new technology that enables conservation, and replacing original inefficient HVAC systems (such as constant volume reheat) with types that comply with existing energy codes. This is consistent with the sustainability direction to adapt campus facilities to utilize electric sources for heating reducing the reliance on combusting fossil fuels. There are specifics in section 7 that follow this theme which includes continuing to reinvest energy cost savings results in additional energy conservation efforts.

2.3 Economic

Illinois has developed a truly sustainable energy conservation program by a commitment to reinvest the energy cost savings from this program to continue improving overall energy system efficiencies. This report includes many of the items that created the success of these investments resulting in a program that is also financially sustainable. Implementation of the strategy to reinvest energy cost savings into the continued energy conservation initiatives have proven to show significant financial returns in addition to meeting the social and environmental goals.

There has been an ongoing effort to utilize energy grants when available. Prior to “The Future Energy Jobs Act” that eliminated *Illinois* from participation in the state’s Energy Efficiency Program we were receiving significant energy conservation grants. We were awarded approximately $16M through that program which assisted in quickly building our robust program. Even though there are not currently grants of that magnitude available, we are monitoring and advocating for reinstatement of that program and/or similar opportunities.

2.4 Social

Illinois’ commitment to provide and maintain a healthy, safe, and effective working and learning environment for all students, faculty, staff, and visitors is paramount in all that we do from our daily tasks to our long-range planning. Our greatest resource and investment is in the many diverse people we serve. We must continually support our campus by providing an environment that is conducive to the world class instruction, discovery, and outreach this university provides. The benefits of a quality environment in our facilities has a value much greater than the cost when considering the improved efficiency and output of those served.

Safety is a core value and a top priority at Facilities & Services. Policies and procedures on safe work practices are in place, and employees are equipped with personal protective equipment (PPE), tooling, and resources to ensure that each work task is completed in the safest manner possible. Employee training and education ensure that our employees understand not only the regulations but also the latest techniques and trends to guarantee that all jobs can be completed efficiently. Safe work practices benefit not only the individual employee but also the entire organization.

2.5 Comparatives with Peers

Facilities & Services benchmarks their performance against peer institutions through Sightlines LLC, a well-known facilities benchmarking consultant. Each year, F&S is compared against their peers in many areas associated with operations, maintenance, capital construction, and utilities. Some of the more important benchmarks with peers involve:

- Campus Density – Gross square feet (GSF) per student
- Energy Intensity – BTUs per gross square foot
- Energy Cost – Dollars of utility spent per gross square foot
- Cost per Student – Dollars of utility spent per student

The following four peer institution comparison tables were included in the Sightlines 2018 update reflecting FY2017 data. Since that time, the UIUC cost per square foot has been $1.30 in FY2018, $1.41 in FY2019, and $1.11 in FY2020. The low cost for FY2020 is attributed to COVID19 reduced campus operations. These calculations reflect fuel and fuel byproduct costs.

Table 1. Campus Density – Gross square feet per student.

Peers	GSF/Student
Illinois	278.1
Iowa	303.0
Indiana University – Bloomington	194.2
Michigan State	370.9
Ohio State	300.6
Penn State	263.9
Rutgers University – New Brunswick	256.3
University of Maryland	228.7
University of Minnesota	351.0
University of Wisconsin – MSN	426.9
Average	**299.5**

Table 2. Energy Intensity – BTUs per gross square foot.

Peers	BTU/GSF
Illinois	127,566.8
Iowa	178,698.4
Indiana University – Bloomington	155,223.4
Michigan State	255,963.8
Ohio State	201,530.4
Penn State	154,108.2
Rutgers University – New Brunswick	188,085.0
University of Maryland	165,414.2
University of Minnesota	151,173.2
University of Wisconsin – MSN	#N/A
Average	**188,357.3**

Table 3. Energy Cost – Dollars of utility spent per gross square foot.

Peers	Total Energy $/GSF
Illinois	$1.36
Iowa	$1.57
Indiana University – Bloomington	$1.77
Michigan State	$1.59
Ohio State	$2.20
Penn State	$1.11
Rutgers University – New Brunswick	$2.34
University of Maryland	$1.85
University of Minnesota	$1.98
University of Wisconsin – MSN	$2.53
Average	**$1.88**

Table 4. Cost per Student – Dollars of utility spent per student.

Peers	Total $/Student
Illinois	$377.44
Iowa	$476.11
Indiana University – Bloomington	$343.36
Michigan State	$588.43
Ohio State	$662.51
Penn State	$292.55
Rutgers University – New Brunswick	$599.76
University of Maryland	$423.74
University of Minnesota	$693.84
University of Wisconsin – MSN	$1,080.00
Average	**$563.06**

3.0 BUDGET AND COST RECOVERY ENTERPRISE SYSTEM

The University of Illinois at Urbana-Champaign allocates its utility costs through the Utilities Enterprise System, a mechanism that fully costs out production, distribution, and capital replacement to each departmental user. The creation and development of the Enterprise System for Budgeting and Cost Recovery, as outlined in the 2007 Energy Task Force Recommendations, has resulted in a transparent, compliant, and consistent accounting for campus utilities. Utility commodity rates are set prior to each fiscal year through a rate case prepared in conjunction with Prairieland Energy, Inc. (PEI) and reviewed with the *Illinois* Office of the Provost and Office of the Chancellor. The Utilities Enterprise System is operated as a self-supporting system and is designed to recover 100% of its costs while, at the same time, providing a rational method of distributing utility costs to buildings.

3.1 Revenue Sources and Customer Base

3.1.1 Metering and Billing

Each of the buildings on campus has at least one billing meter per commodity. Commodity usage is therefore identified to each building based on its actual off-take from our utility network. Each building is subdivided into responsibility areas derived from the Archibus space management system using net assignable square footage (NASF) as the determining factor. The responsibility areas are most often individual campus departments, so usage can be identified by individual departments. Using the Banner Organization hierarchy for our campus, we can roll up individual departments into higher-level organizations such as College or Administrative units.

3.1.2 Billing Software

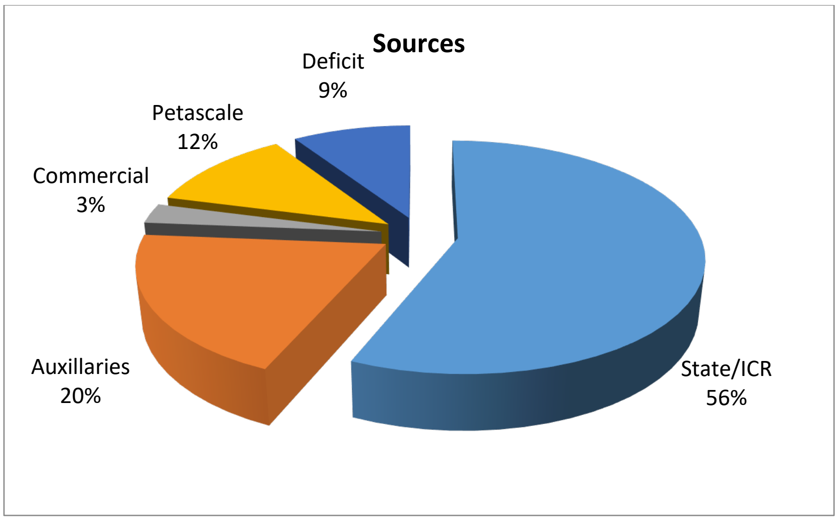
The computer software that is used for this purpose is “EBS” (Energy Billing System) from Aveva Software, which takes the meter information, divides the usage across the responsibility centers, and applies the current utility rate to bill out utility costs. The system produces invoices available on a website, as well as user-friendly charts and graphs allowing the user to understand and chart utility usage. This provides users with transparent, accessible energy usage information.

This software is at the end of life and we are presently looking at an upgrade that would include getting more information out to the buildings at kiosks.

3.1.3 Customers

Illinois’ customer base can be divided into four categories (State/ICR, Auxiliary, Commercial, and Petascale) with each category corresponding to a funding source (see Figure 1). State-supported customers have their usage billed against a central fund maintained on the Facilities & Services ledger. While not billed directly to customers, the billing system produces a utility bill that shows how much was billed to the central account on behalf of the department incurring the cost. This fund is by far the largest part of our customer base and accounts for 65% of the total Enterprise revenue (56% State/ICR + 9% Deficit). Campus auxiliaries (i.e. Housing, Illini Union, Athletics, Campus Recreation, the Airport, and McKinley Health Center) are billed directly to their operation. Their revenue is derived from student or public charges rather than the central state fund.

Auxiliary usage accounts for 20% of the total Enterprise revenue. Commercial customers (mostly buildings in South Research Park) account for 3% of the total Enterprise revenue. Commercial customers are billed and pay for their utility costs directly. Lastly, we have an NSF grant that gets billed in support of the National Petascale Computing Facility's cost for the Blue Waters petascale computing project. This accounts for 12% of the total Enterprise revenue. All of the customers are provided with detailed utility bills showing their month-to-month usage and cost by commodity for their facility. Providing this information gives our customers valuable feedback in developing building-centric conservation strategies.



State/ICR	Auxiliaries	Commercial	Petascale	Deficit
$48,939	$17,184	$2,417	$10,088	$8,046
56%	20%	3%	12%	9%

Figure 1. Total Enterprise Revenue (All Figures in $1,000 U.S. Dollars)

3.1.4 Future Plans

While the billing system is a means of providing relevant information to building managers and finance managers, it is a passive system that requires users to visit the F&S website and pull the data directly from the application located on the server. A request for proposal (RFP) targeting a replacement of the existing software system with a system that provides more real-time access to the ultimate customer through interactive web tools and dashboards is being prepared. These tools will further engage our customers and aid in identifying potential areas for energy conservation.

3.2 Utility Rate Development

Utility rates for campus utilities (steam, electric, chilled water, water, and sanitary) are approved by the Office of the Provost annually. Every two years, the Office of Government Costing and F&S reconcile the actual utility costs in preparation of the F&A Cost Proposal submitted by campus. The budgeted utility rates are composed of the following elements:

- Fuel and purchased utility (electricity, water, sanitary, and natural gas) costs
- Chemicals
- Cost to distribute utilities to buildings
- Operations and administrative overhead costs
- Budgeted maintenance costs
- Major repair/replacement and capital replacement costs
- Debt service
- Reduction in existing utility deficit
- Over/Under recovery of prior year operating deficits

The Fuel and Purchased Utility costs include the various costs associated with delivery and other related charges. *Illinois* participates through Prairieland Energy Inc. (PEI) in numerous processes to evaluate and minimize these charges. Total utility costs by commodity are divided by the forecasted production or usage estimated for each commodity to develop a per-unit rate that is used in the billing system to allocate costs to each customer. Annually, the amount recovered, whether greater than or less than budget, is factored into the following year's rates so that the cost is 100% fully recovered over time.

4.0 SUPPLY SIDE OF CAMPUS ENERGY

4.1 Supply Side Infrastructure

University staff maintains and operates Abbott Power Plant (APP) and seven chilled water facilities that include Oak Street Chiller Plant, North Campus Chiller Plant, Library Chiller Plant, Animal Science Chiller Plant, Chemical Life Science Chiller Plant, Veterinary Medicine Chiller Plant, and the Thermal Energy Storage (TES) Tank and Pump Building. These facilities provide **steam**, **electricity**, and **chilled water** to the *Illinois* campus.

4.2 Steam

Built in 1941, Abbott Power Plant has been continuously operated as a combined heat and power (CHP) plant with the majority of steam exported to the campus passing through backpressure steam turbine generators. Steam is not produced at any additional facilities on campus. APP operates six boilers and two combustion turbines with heat recovery steam generators (HRSG) with a combined capacity of over 1,000,000 pounds of steam per hour (pph.) HRSG is a highly efficient form of combined heat and power. Cogeneration is considered the most sustainable method of providing energy from fossil fuels and is beneficial because it increases energy efficiency, decreases costs, results in lower overall emissions, and diversifies our energy supply.

4.2.1 Coal Boilers

APP operates three coal boilers. Boilers 5 and 6 have a rated capacity of 150,000 lb/hr each, and boiler 7 has a rated capacity of 190,000 lb/hr. Each boiler is equipped with an electrostatic precipitator that helps to remove particulate from the stack, and there is a common flue gas desulfurization system (Chiyoda Jet Bubble Reactor) that removes the sulfur from the flue gas.

4.2.2 Natural Gas Boilers

APP operates three natural gas boilers, which are also equipped to run on fuel oil as an emergency backup. Each of the three boilers have a rated capacity of 175,000 lb/hr and are equipped with low NOx burners and flue gas recirculation to reduce the overall NOx emissions from the boiler. These upgraded boilers were installed and put into operation between 2015 and 2018.

4.2.3 Heat Recovery Steam Generators

APP operates two Heat Recovery Steam Generators (HRSG), which operate in series downstream of a gas (combustion) turbine. Each HRSG in the unfired condition can generate approximately 45,000 lb/hr of steam, and are also equipped with duct burners that when fired can increase the steaming capacity of the HRSGs up to 110,000 lb/hr.

4.2.4 Recent Projects

The Utilities Production and Distribution Master Plan recommended that several projects be undertaken to improve the reliability and efficiency of Abbott. Most of those projects have either been completed or are in process.

4.2.4.1 Add Backpressure Steam Turbine Generator

Installing a new backpressure (BP) steam turbine generator (STG) was evaluated against the option of converting one of the existing STG with a condenser to a BP unit. It was determined that the best option was to convert one of the newer Siemens STGs (#8) to a backpressure unit. An agreement was reached with the OEM, Siemens, to complete the design upgrade and manufacture all of the new components. The purchase order for this project was issued in September 2016, and the project was completed in December 2017.

4.2.4.2 Replace/Repair HRSG 1 and HRSG 2

Work on the repair of HRSG1 was completed in June 2019. The repair of HRSG2 was completed during the winter of 2019/2020. Both units underwent significant repairs which included work on the superheater tubes and header, generating bank tubes, as well as a rework of the casing and insulation. It is anticipated that the repairs will allow the HRSGs to operate reliably and safety for the next 10+ years.

4.2.4.3 Add Third Gas Boiler

Two projects have been undertaken over the course of the last six years that have resulted in the installation of three new natural gas-fired boilers at Abbott. The first project involved the replacement of a gas boiler that had been retired in place, and the second project involved the replacement of the two operating natural gas-fired boilers that were at the end of their useful life. The planning and scheduling of these projects was critical. The work had to be executed in a fashion that ensured that there was always adequate assets to serve the campus and that these major capital projects had minimal impact on the continuous safe and reliable operation of Abbott.

The new boilers that were installed included an increase in operating pressure from 350 psi up to 850 psi. This increase in pressure facilitated an increase in our ability to cogenerate electricity and resulted in our ability to cogenerate close to twice as much electricity from the same volume of steam. The new boilers are equipped with high efficiency/low NOx burners, resulting in improved emissions as compared to the old boilers. The three new boilers are anticipated to provide safe and reliable service to the Urbana campus for the next 20 years. All three boilers are also equipped to operate on fuel oil in the event of an emergency which results in a loss or decrease of natural gas service to Abbott.

4.3 Electricity

Illinois has its own Electrical Distribution (ED) system that provides power to the vast majority of the campus buildings. The campus' ED system is supplied power from our Abbott Power Plant cogeneration assets, our on-site solar, or from the two separate 69 KV services by the local utility (Ameren) from two directions. Those two feeds are capable of importing full capacity from either Ameren Substation (from North Champaign or from the South-West Sub). Those feeds enter our Main Campus Substation through a ring bus with both services connected with automated switching by Ameren to maintain reliability if one circuit would fail. Our 13.8 KV generators at Abbott also connect to our Main Campus Substation that has redundant circuits with automated switchgear that allows both our generator power and imported power (stepped down to 13.8 KV) to feed our ED. From our Main Substation, our power circuits are routed through underground duct banks first to campus' Distribution Centers with redundant circuits and automated switching and then to load centers and buildings. Our ED has a second 69/12.47 KV "Southeast Campus Substation" that is fed from the 69 KV switches at our Main Sub that mirrors the 13.8 KV infrastructure. The 69/12.47 sub was provided with our ED upgrade to integrate campus buildings and 12.47 ED that was originally fed from Ameren directly.

An economic dispatch model determines the most cost effective operation which typically results in co-generation of electricity based on the steam needs of campus with supplementary power purchase to meet the campus load. Demand Resources (such as Thermal Energy Storage) are utilized to strategically shape the load to further enhance the economic benefits of our central systems.

APP operates two gas/combustion turbines, six steam turbine generators (STG) that can operate in either condensing or backpressure mode, and three steam turbine generators that operate in backpressure mode, with a combined nameplate capacity of 78 MW. Actual generating capacity is dependent on available steam production and steam demand on campus.

4.3.1 Steam Turbine Generators

APP operates nine steam turbine generators that vary in age of installation from 1940 to 2000. STGs 1-4 are all General Electric machines that are designed for an inlet steam pressure of 325 psi and are each capable of generating up to 3 MW. STGs 1, 2, and 4 are all backpressure/condensing turbines, while STG 3 is a backpressure only unit. All of these units in back pressure mode supply the 50 psi steam header in APP.

STGs 6 and 7 are both General Electric machines that are designed for an inlet steam pressure of 850 psi and are each capable of generating up to 7.5 MW. They are both backpressure/condensing turbines, which in backpressure mode supply the 50 psi steam header in APP.

STGs 8, 9, and 10 (the newest units at APP) were installed as part of the plant addition that was started in 2000. They are all Tuthill-Murray (Siemens) designed machines. STG 8 and 9 were both designed for an inlet steam pressure of 850 psi capable of generating up to 12.5 MW. They were both designed as back pressure/condensing turbines, which in back pressure mode supply the 150 psi header in APP.

STG 10 is an extraction/back pressure unit, designed for an inlet steam pressure of 850 psi. In extraction mode this unit supplies the 150 psi header, and in back pressure mode it supplies the 50 psi header. STG 10 is capable of generating up to 7.5 MW.

4.3.2 Combustion/Gas Turbines

The 2000 plant addition included the installation of two new combustion/gas turbines (GT). They are both SOLAR Titan 130 machines, capable of operating on both natural gas and fuel oil. The nameplate capacity of each unit is 12.5 MW, but the engine and generator are capable of producing up to 15 MW. See Section 4.3.4.4 for details on the recent Turbine Inlet Cooling project.

4.3.3 Solar Farm 1.0

Phoenix Solar, Inc., was hired by the university in 2015 to design, build, and operate a Solar Farm on university property. The Solar Farm produces approximately 7,200 megawatt-hours (MWh) annually or approximately 2% of the annual electrical demand for the Urbana campus making this site one of the largest university solar arrays in the country.

The university signed a 10-year power purchase agreement with Phoenix Solar to purchase all electricity produced by the Solar Farm and deliver it directly to the campus grid. In addition, the university will own/receive all current and future Renewable Energy Certificates (RECs) and emission credits associated with energy from the 4.68 megawatt (MWac) Solar Farm.

4.3.4 Recent Projects

There have been several reviews and evaluations of potential upgrades, some of which are items recommended by the 2015 Utility Production and Distribution Master Plan.

4.3.4.1 Installation of two new 1 MW "Black Start" generators at Abbott

4.3.4.2 Project with Ameren to increase electrical import capacity to 90 MW

4.3.4.3 Project installing a Power Management Control System (PMCS) that allows automated load shed and generation stability to be able to operate in "Island Mode" without the electric grid

4.3.4.4 Inlet cooling for combustion turbines

In calendar years 2016/2017, an ESCO contract was issued which installed cooling on the inlet air ducts for both combustion turbines (CT). By cooling the inlet combustion air as the outside temperatures start to increase above 65°F, engine performance and the output from the combustion turbine can be maintained. Without cooling the outside air that is used for combustion, engine performance starts to decrease as the temperature increases, and the amount of electricity it can generate decreases as well. Without cooling in the summer, the CTs performance would drop from a peak of 15 MW down to a low of 11 MW. With inlet cooling, the performance is always maintained at or above 13 MW. The additional generation capacity from the CTs is very valuable in the summer because power prices typically peak during the hot summer days. In addition, the extra capacity can be offered into the demand response market for the electric gird in our region (MISO), and serves as source of revenue that lowers our overall operating cost.

4.3.4.5 Conversion of STG 8

In 2017, the steam path on STG 8 was redesigned, and it was reconfigured into an extraction/back pressure unit, very similar in design to STG 10. The newly configured machine supplies the 150 psi header in extraction mode, the 50 psi header in back pressure mode, and is capable of generating up to 7.5 MW.

4.3.4.6 Solar Farm 2.0

On September 19, 2019, the Board of Trustees approved PEI to contract with Sol Systems, LLC to construct and operate Solar Farm 2.0 at a contract cost of $20,143,045 for a 20-year term.

A Power Purchase Agreement (PPA) was executed by PEI and Sol Systems, LLC on December 3, 2019. The PPA has been assigned to Northern Cardinal Solar SCS IL 1 (NCS). PEI assisted with the execution of the land lease and interconnection agreements between the University of Illinois and NCS.

Construction started in July 2020 on Solar Farm 2.0 located North of Curtis Road, between Route 45 and 1st Street. Commercial Operation Date is scheduled to be January 31, 2021. The Solar Farm will have 399 rows, 31,122 solar panels and is designed to produce 20,256 Mwh's of renewable energy in the first year.

4.4 Central Chilled Water

Air conditioning for campus buildings began with small unitary equipment and by installation of chillers serving only the buildings they were installed in. An area within the Main Library was developed to start a small air conditioning center to serve some of the buildings on the Quad. The scattered buildings with air conditioning and the center in the Library utilized steam as the energy source for cooling. This was mainly because Abbott's CHP production and the campus-wide central steam system was adequately developed and available to provide building-wide cooling with low pressure steam absorption chillers. Those chillers served campus well when air conditioning was being developed but when they reached the end of their useful life and major maintenance funding to further extend their use was no longer feasible, an engineering study was required to determine the best path forward. The results of that 1997 study resulted in a campus cooling master plan that initiated the development of a campus-wide Central Chilled Water System (CCWS). The development of that system continues to provide an efficient and reliable cooling source for existing buildings where original building chillers have failed and for the ever-expanding air conditioning loads from new buildings and major renovations.

The central system now has five chiller plants that provide chilled water to over 125 campus buildings. The North Campus Chiller Plant (NCCP) 9400 tons and the Library Plant 4340 tons were originally regional plants that were converted to the CCWS. The Animal Science Chiller Plant (ASCP) 2000 tons and the Chem Life Science Plant 3630 tons were originally single building chillers that were expanded and converted. The Oak Street Chiller Plant (OSCP) was built for the development of the CCWS and was brought on line in 2004. The OSCP original equipment produced 12,000 tons of cooling with 10,000 tons from steam turbine drive chillers. The plant was built capable of adding capacity and currently produces up 27,700 tons. Increases in chilled water production also increase the load on the *Illinois* Electrical Distribution System and their infrastructure plans must be compatible.

The National Center for Supercomputing Applications (NCSA) was successful with a grant for the Blue Water supercomputer, and a new National Petascale Computing Facility (NPCF) was built to house it. The need for its additional 5400 tons of cooling coupled with the development of the central system enabled an option of a Thermal Energy Storage (TES) system to serve that load. Utilizing TES greatly enhances the CCWS operation by enabling chilled water production to shift from peak daily electrical rates to off-peak nightly rates. This shift also reduces campus peak demand to reduce capacity charges from MISO.

Our central chilled water system has 47,000 tons of chilled water production with our 6.5 million gallon TES tank capable of contributing another 8,000 tons of cooling during the peak of the day.

4.4.1 Recent Projects

The Utilities Production and Distribution Master Plan recommended that several projects be undertaken to improve the reliability and efficiency of the chilled water system. Most of those projects have either been completed or are in process. Details of each project are listed below.

4.4.1.1 Apply Heat Recovery Chiller Technologies

Heat Recovery Chillers have been added in three buildings and projects are underway to add them in four other buildings, two of which will also serve adjacent buildings. This allows us to efficiently provide heat to these facilities from an electric energy source positioning us to further reduce greenhouse gas emissions in the future.

4.4.1.2 Replace Chillers at Library Chiller Plant

The Library Chiller Plant has recently been upgraded with two new high efficiency variable speed drive chillers removing two of the old inefficient machines that were at the end of their useful life.

4.4.1.3 Replace Towers at Vet Med Chiller Plant

Two cells of cooling towers at the Vet Med Chiller Plant have been replaced increasing capacity and providing more efficient operations.

4.5 Fuels and Purchased Utilities

Illinois works with Prairieland Energy, Inc. (PEI) to procure fuels and utilities for the campus. Prairieland Energy, Inc. (PEI), is an *Illinois* corporation founded in 1996 that is solely owned by the University of Illinois Board of Trustees and functions as a university-related organization. PEI’s primary mission is to provide energy commodities that support the reliable provision of energy services to the University of Illinois campuses while achieving an effective balance of cost efficiency, acceptable price volatility, and desired budget certainty. PEI also provides electric, steam, and chilled water utility service to residential and commercial customers in non-university buildings on University of Illinois property.

For the past several years, PEI has retained an energy consultant/market advisor to help oversee and manage the procurement of natural gas and electricity for the university. This consultant has served several functions including serving as the primary point of contact for both our natural gas and electricity contracts, assisting with our reporting requirements with MISO and our natural gas supplier, daily purchases, monthly bill reconciliation, and review and execution of futures purchases for both natural gas and electricity.

As you will note from the description that follows, the university has retained three separate fuel types to serve the campus. History has taught us that fuel flexibility is important to help insure price stability and service reliability. One of the notes from the master plan was to “enhance the existing best-in-class diversified fuel cogeneration plant”, and the plan emphasized the value of maintaining fuel flexibility for the university.

4.5.1 Natural Gas

4.5.1.1 Natural Gas Purchasing

Natural gas purchases are managed with the assistance of a market advisor. The university and PEI work together to establish an annual budget that starts by estimating the anticipated steam and electric load for the campus. Based on these estimates, the university then estimates the amount of fuel that will be required to meet the steam demand. In conjunction with this estimate, the amount of electricity that will be produced from the fuel consumed and the amount of electricity that will need to be purchased above and beyond what is generated is also calculated (this will be discussed further in Section 4.5.3).

The energy requirements (natural gas, coal, electricity) are projected for five years out, and these projections are used as part of a hedge program for the future purchase of natural gas. With assistance from our market advisor, the university works with PEI to determine volumes and price points for future purchases of natural gas, with the overarching goal of providing budget certainty as well as cost effective utilities. The hedging program is looking out a minimum of three years, and making purchases as opportunities become available to meet the overarching goals.

The market advisor plays the primary role managing our daily purchases of natural gas, as well as working to ensure that our daily and monthly balancing are operated efficiently. The market advisor works directly with the operations staff at Abbott Power Plant to identify the daily needs for natural gas and is the interface with the market to manage those requirements. At the end of the month, the market advisor helps to reconcile all bills.

4.5.1.2 Natural Gas Delivery

The main natural gas supply to the campus system is provided via *Illinois'* 8-inch pipeline that runs parallel with Curtis Road. The university installed this high pressure natural gas transmission line at the time of Abbott's north expansion with Combustion Turbines, and we own and operate it in accordance with regulatory requirements. This pipeline is connected to the Kinder Morgan NGPL interstate pipeline near Monticello in Piatt County. We have a contract with NGPL for firm delivery but there are occasions of reduced flow within tariff requirements.

Our pipeline provides natural gas at a pressure of approximately 700 psig (with a maximum operating pressure of 858 psig and capacity of 3.5 mcf/hr) to a pressure reducing station located on the corner of Curtis Road and Neil Street (Route 45). The natural gas pressure is reduced to approximately 400 psig and is then directed to Abbott Power Plant in a 10-inch steel line with a maximum operating pressure of 618 psig. Once this piping reaches APP, most of the natural gas is used for APP steam boilers and combustion turbines, while a portion of the natural gas is reduced to 40 PSIG and distributed to the Research Park and a few south campus buildings. Many of the campus buildings continue to be served by the Ameren natural gas system that remained in place for smaller low pressure loads.

The University also maintains a second/separate connection to an Ameren low pressure gas system at Abbott Power Plant. In the event of an interruption of service to the university owned gas transmission pipe to Abbott, the university can utilize the Ameren connection to serve gas boilers at Abbott (but not the combustion turbines), as well as serve the loads in the Research

Park. This secondary connection is one of several redundant fuel delivery systems to help ensure reliable service to our campus customers.

4.5.2 Coal

Coal is bid out through the campus/state procurement process. The coal contract includes the delivered price for coal, as well as the haul back of ash and gypsum for disposal/reclamation at the coal mine. These contracts are bid out as necessary and typically include renewal options for several years. Historically, the coal contracts have included a price that is fixed for the fiscal year, with a monthly adjustment allowance for changes in the price of diesel fuel which impacts the delivered price for the coal (since it is delivered with a tractor/trailer).

4.5.3 Electricity – Purchased

4.5.3.1 Hedge Purchases

Similar to natural gas, university electricity purchases are managed with the assistance of a market advisor. Based on the annual budgets, projected electricity generation and purchases are estimated. These requirements are projected for five years out and used as part of a hedge program for the purchase of electricity.

With assistance from our market advisor, the university works with PEI to determine volumes and price points for future purchases of electricity, with the overarching goal of providing budget certainty as well as cost effective utilities. The hedging program is looking out a minimum of three years and making purchases as opportunities become available to meet the overarching goals.

The market advisor plays the primary role managing our daily purchases of electricity. The market advisor works directly with the operations staff at Abbott Power Plant to identify the daily electricity generation volumes and couples that information with the projected daily demand to manage the daily purchasing requirements. The market advisor serves as interface with the market to manage those daily requirements. At the end of the month, the market advisor helps to reconcile all bills.

4.5.3.2 Power Purchase Agreements (PPA) – Renewables

Solar Farm 1.0
Illinois Board of Trustees approved construction of a 20.8-acre solar farm in November 2012. The construction was delayed due to changes in State of Illinois procurement laws. Located along the south side of Windsor Road between First Street and the railroad tracks, Solar Farm 1.0 has been operational since December 11, 2015.

Phoenix Solar Inc. was hired by the university in 2015 to design, build, and operate the Solar Farm at the Windsor Road site. The Solar Farm produces an approximately 7,200 megawatt-hours (MWh) annually or approximately 2% of the annual electrical demand for the Urbana campus making this site one of the largest university solar arrays in the country.

The university signed a 10-year power purchase agreement (PPA) with Phoenix Solar to purchase all electricity produced by the Solar Farm and deliver it directly to the campus grid at a fixed rate for the length of the PPA. In addition, the university owns/receives all current and future

Renewable Energy Certificates (RECs) and emission credits associated with energy from the 4.68 megawatt (MWac) Solar Farm.

Research estimates the Solar Farm will generate up to 91% of its original output even in year 20 of the project.

Wind PPA

From November 2016 through October 2026, the Urbana campus will receive a percentage-based portion of the wind-generated electricity and associated environmental attributes from the Rail Splitter Wind Farm located north of Lincoln, Illinois. The PPA specifies that 8.6% of the total wind generation from the farm will be sold to the university, which is expected to be an annual amount of more than 25,000 megawatt-hours (MWh). The Wind PPA has a fixed rate for the entire 10-year PPA term.

Solar Farm 2.0

The university and PEI entered into an agreement with Sol Systems to construct and operate a 54-acre 12.32 megawatt (MWdc) solar farm on university-owned property. This installation will generate approximately 20,000 MWh annually, and the PPA is for a fixed rate 20-year term. This project is scheduled to be operational in January 2021.

4.5.4 Fuel Oil

The university owns and operates two fuel oil storage tanks, with a total capacity of 2 million gallons. These tanks provide fuel oil that can be burned in both the natural gas boiler and the gas turbines installed at Abbott Power Plant. The fuel oil can be utilized as an emergency backups in the event of a loss of natural gas and/or coal.

5.0 DEMAND SIDE OF CAMPUS ENERGY

5.1 Energy Use Goals and Trends

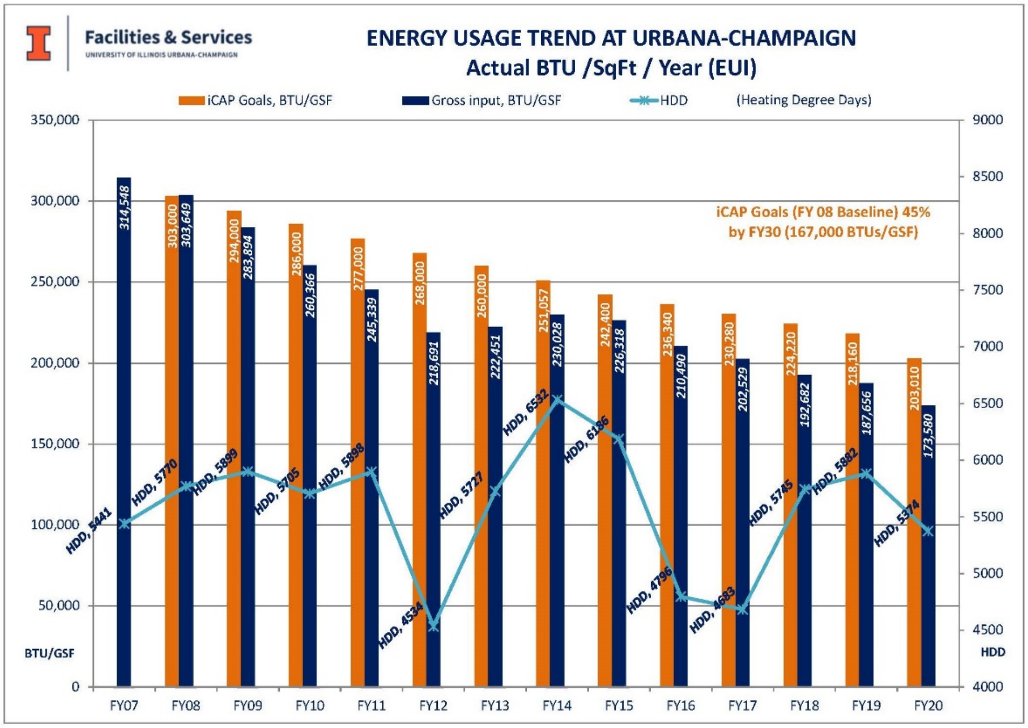
5.1.1 Previous Energy Reduction Goals

- 2008 - Chancellor signed the American College & University President's Climate Commitment and campus began work on the associated Climate Action Plan.
- 2008 – Chancellor's Press Release included: "The University of Illinois at Urbana-Champaign has established a goal of reduction the energy consumption of existing buildings by 10 percent over the next three years and has established a five-year target of rolling back usage to 1990 standards."
- 2010 – Illinois Climate Action Plan (iCAP) completed including reducing energy consumption in existing buildings by 20% by 2015; 30% by 2020; and 40% by 2025.
- 2015 – Illinois Climate Action Plan was updated, including a goal to improve the energy utilization intensity (EUI) from the FY08 Baseline by 33% by FY20, 38% by FY25, and 52% by FY50, with the associated goal of reducing total energy demand by 50% by 2050, compared to the baseline of FY08.

5.1.2 Energy Usage and Trends

The current energy conservation campaign started in 2006 with a commitment to follow the United States Green Building Council's (USGBC) LEED building standards, development of the Retrocommissioning program in 2007, and the first round of campus building lighting upgrades. This was in conjunction with Chancellor Herman who made a commitment for energy reduction in his May 15, 2008 press release and the President's Energy Task Force review which concluded with a final report to the Board of Trustees in 2009. The Energy Utilization Index (EUI) is an industry standard metric that was adopted to set goals and track energy conservation progress. The EUI takes the measured energy inputs to campus divided by the total gross square feet served on an annual basis. *Illinois* began tracking progress in 2007 (see Figure 2). The 2010 iCAP effort utilized this metric compared to the FY 2008 baseline to establish the aggressive reduction goals of 20% by FY 2015, 30% by FY 2020, and 40% by FY 2025.

Figure 2. Energy usage trend for Actual BTU/Sq.Ft./Year (EUI).



5.2 Energy Conservation Progress

5.2.1 Retrocommissioning (RCx)

Retrocommissioning (RCx) is one of many programs driving *Illinois'* success in energy conservation. RCx optimizes a building's heating, ventilation, and cooling systems and controls to maximize energy savings while maintaining occupant comfort.

Since 2007, RCx teams have updated and upgraded systems in 80+ campus buildings, reducing energy consumption by an average of 27% and avoiding over $72M in utility costs for over 10 million gross square feet of facilities. RCx will continue to pay dividends in energy savings and efficiency gains as deferred maintenance is taking a toll on campus buildings, wasting energy, and consuming financial resources.

Retrocommissioning activities cost just over $18M since FY07, resulting in a very productive return on investment, resulting in over $72M in avoided costs. Positive acknowledgement from university administration demonstrates the impact this work has on campus.

Recognizing the potential for savings, some campus units (e. g. Campus Recreation, Illini Union, Memorial Stadium, McKinley Health Center, and Electrical and Computer Engineering) have funded RCx services directly.

Some projects following RCx tend to significantly affect the overall avoided building energy consumption numbers. For example, the Grainger Engineering Library steam absorption chiller was retired and the campus chilled water loop was connected to the building after RCx.

5.2.1.1 Current Projects

RCx is currently focused on older buildings that have recently completed renovation projects. For example, significant cost savings is available through applying occupancy schedules in chemistry teaching labs and reducing occupancy hours during the summer. Retrocommissioning is collaborating with planners and building occupants for future renovation projects at Noyes Lab. RCx is working with Deferred Maintenance to improve their information and/or prioritization of future projects.

5.2.1.2 Future Projects and Energy Reduction Goals

Currently, RCx is staffed to accommodate retrocommissioning on approximately 500,000 square feet per year. During the next few years, we expect to analyze and commission 500,000 sq. ft. each year with energy savings to be between 5,000 MMBTUs and 18,000 MMBTUs per year. This amounts to between a 8% to 25% reduction of the energy consumption in buildings visited.

5.2.1.3 Funding

Initially, RCx was funded by the students and staff of the Academic Facilities Maintenance Fund Assessment (AFMFA) committee. They are no longer funding RCx efforts.

Prior to FY18, a significant amount of RCx funding came from the State of Illinois Department of Commerce and Economic Opportunity (DCEO). This program has been discontinued after awarding the university $16M in energy rebates and grants. This represents a significant funding loss going forward. The energy grant funds allowed us to build a fund surplus that was utilized to continue this initiative for several years with no other funding. It is now supplemented with a $529,000 contribution from state funds (available from energy cost savings).

5.2.1.4 Outreach

For the past three years, *Illinois* has competed in the International Laboratory Freezer Challenge, a competition designed to promote best practices in cold storage management. Participating universities reduce their energy consumption, costs, and environmental impact of their labs while maximizing lab space utility. The Freezer Challenge then rewards the campus that was able to turn off the most freezers by getting rid of samples and maintaining the equipment for optimal energy performance. By reaching out to the campus community to identify freezers that could be turned off, Retrocommissioning has helped *Illinois* win this prestigious award in both 2018 and 2019.

Illinois also sponsors the ECO-Olympics, a 3-week energy savings competition that educates and motivates students in residence halls to change their behavior and reduce their energy usage. In 2019, 350 students across 17 residence halls saved 70,000 kWh of energy.

In addition to these competitions, Retrocommissioning also monitors campus fume hood usage and has helped shut down unused fume hoods when departments move out of buildings and/or when teaching labs are closed during the summer.

5.2.2 Re-Commissioning (ReCx)

Re-commissioning (ReCx) is a process that seeks to improve how building equipment and systems function together. Depending on the age of the building, ReCx can often resolve problems that occurred during design or construction and address problems that have developed throughout the building's life. ReCx improves a building's operations and maintenance (O&M) procedures to enhance overall building performance.

Buildings frequently undergo operational and occupancy changes that challenge the mechanical, electrical, and controls systems hindering optimal performance. Additionally, in today's complex buildings, systems are highly interactive with sophisticated control systems that can create a trickle-down effect on building operations – small problems have big effects on performance. The overall goal is to produce a building that meets the unique needs of its owner and occupants, operates as efficiently as possible, and provides a safe, comfortable work environment.

The goals of the ReCx process are:

- Enhance documentation of the operational and maintenance (O&M) requirements for the HVAC equipment
- Document baseline operating conditions through trending of performance measurements
- Optimize control systems through calibration of critical sensors, review metered data and trend logs, and perform functional equipment testing
- Identify operational and maintenance enhancements that result in improvements in energy efficiency, occupant comfort, or indoor air quality

Typical spinoff projects associated with ReCx visits are:

- Control upgrades
- Occupancy sensor installations
- Damper replacements

A review of the prior retrocommissioned (RCx) buildings was performed where utility usage of eleven buildings was totaled prior to the visit and each year for five sequential years after the visit. The results indicate that the initial energy savings realized from the RCx visit started to revert back – an increase of approximately 43% between the second and fifth year (see Figure 3).

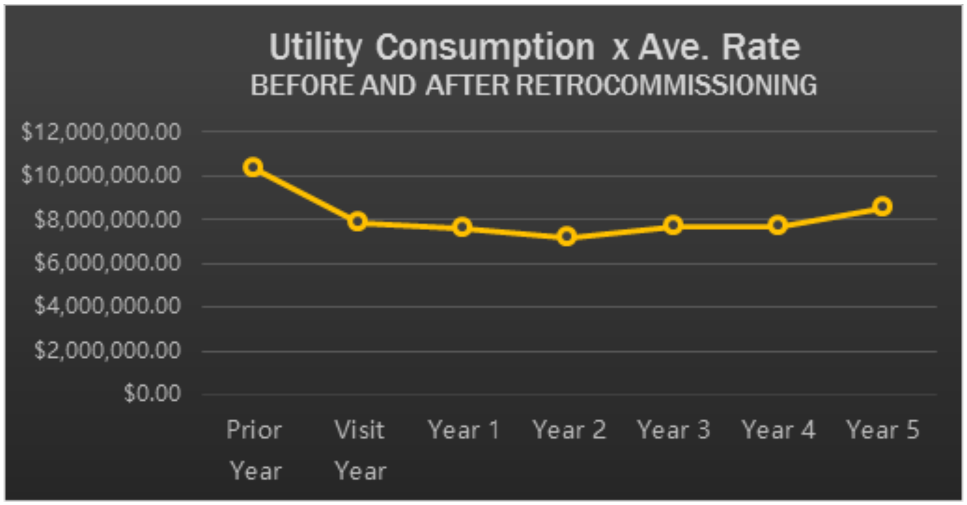


Figure 3. Utility Consumption by Average Rate Before and After Retrocommissioning

There are currently five composite ReCx teams. The plan is to establish six teams, one for each temperature control route. The goal is for each ReCx team to visit the buildings on their various routes on a three-year interval to sustain or enhance energy savings and maintain or improve occupant comfort and indoor air quality.

5.2.3 Energy Performance Contracting

Energy Performance Contracting (EPC) is a project delivery method focusing primarily on energy/utility reduction. The EPC process is a multiple contract process where the university contracts with a qualified Energy Service Company (ESCO) to provide all of the services required to design and implement a comprehensive project at the customer facility, from the initial energy audit through long-term guarantee of project savings.

The university uses this process to manage conservation programs at complex facilities with high energy use, such as laboratories, making them energy efficient and addressing deferred maintenance issues along the way.

Illinois has executed over $100M of Energy Performance Contracting projects starting with the Veterinary Medicine facilities in 2010 which resulted in an estimated cost avoidance of $1M annually. A contract for the Oak Street Chiller Plant helped campus avoid an additional $1.2M annually. A project at Abbott Power Plant improved efficiencies for the gas boilers which results in approximately $200K in annual savings. Recently completed, five College of Engineering buildings are estimated to help campus avoid $1.5M the first year after construction alone. Construction is currently underway in six laboratory-type buildings that is expected to save approximately $2M annually. To date, 17 buildings have been impacted by the EPC delivery method resulting in guaranteed savings of approximately $6M annually. Additionally, two projects have been recognized by ASHRAE and presented with multiple awards for design and performance.

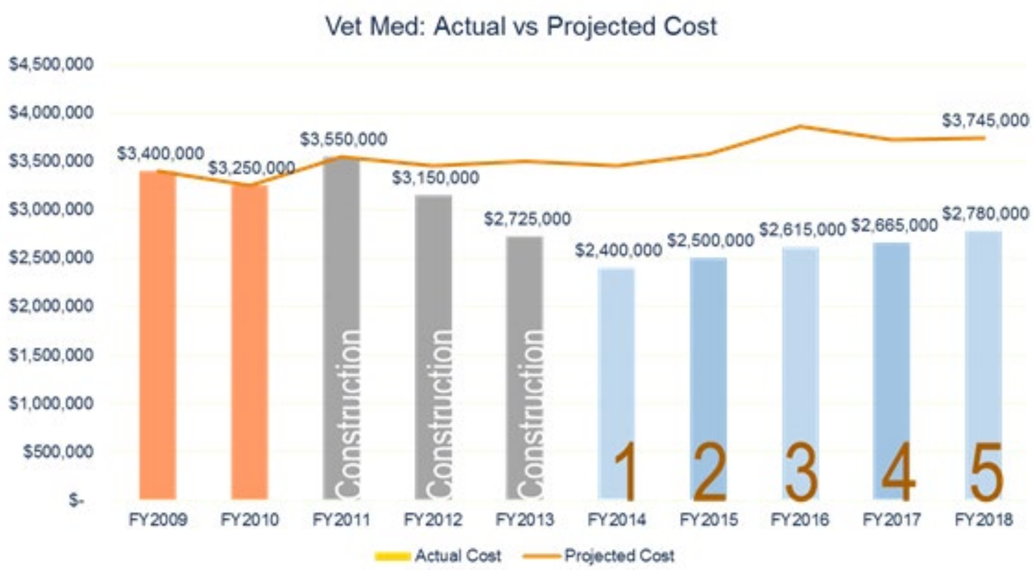
5.2.3.1 Current Projects

Laboratory Facilities – EPC Project 05 (U16061)
In May 2018, the Board of Trustees approved Schneider Electric to implement energy conservation measures at six locations including Chemical & Life Sciences Laboratory, Roger Adams Laboratory, Illinois Sustainable Technology Center, Beckman Institute, Natural Resources Studies Annex, and Forbes Natural History Building. Construction activities commenced in January of 2019. Substantial completion of this approximately $32M project is expected in October 2020.

5.2.3.2 Completed Projects

College of Veterinary Medicine – EPC Project 01 (U11026)
With a contract valued at $21.26M, the Veterinary Medicine project marked the university's foray into energy performance contracting. The project provided a long-term financing solution for modernizing the facilities and their energy infrastructure. It eliminated $25M in deferred building maintenance while improving air quality, lighting, occupant comfort, and more reliable heating and cooling. Today, the project continues to avoid more than $1M in estimated energy costs annually (see Figure 4).

Figure 4. Veterinary Medicine: Actual vs Projected Cost.

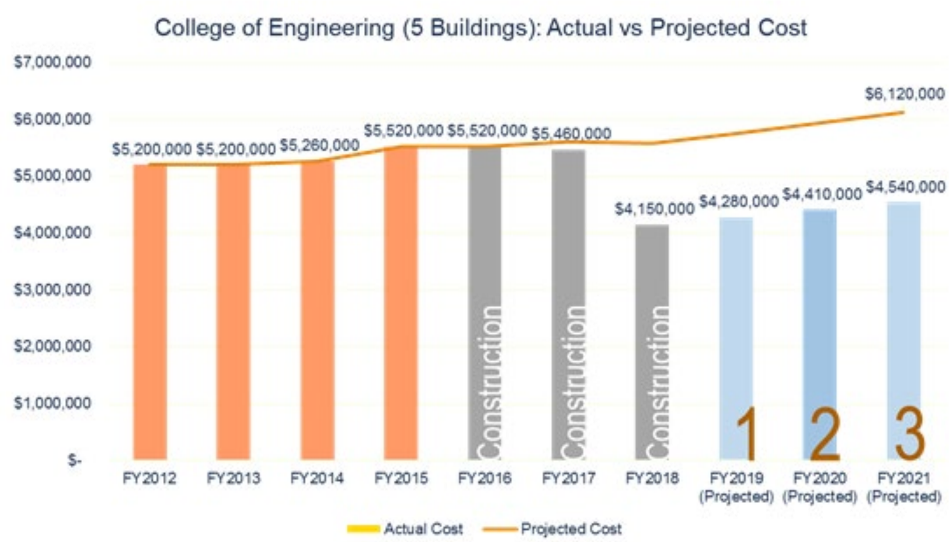


Oak Street Chiller Plant – EPC Project 02 (U11080)
This $10.7M project included the installation of two electric, high-efficiency, large-tonnage chillers; a cooling tower; a refrigerant storage unit; and a 10 mVa transformer. It gives the university greater flexibility in choosing a fuel source for cooling generation and an estimated energy savings of $1.2M annually.

College of Engineering – EPC Project 03 (U14076)

In July 2015, the Board of Trustees approved Energy Services Group, LLC, to implement an approximately $41M project which includes energy conservation measures for Micro and Nanotechnology Laboratory, Seitz Materials Research Laboratory, Loomis Laboratory, Engineering Sciences Building, and the Superconductivity Center. The project is now substantially complete (see Figure 5). Estimated reduction in MMBTUs for the first year the project is complete is 80,570 MMBTUs.

Figure 5. College of Engineering: Actual vs Projected Cost.



Abbott Power Plant – EPC Project 04 (U15057)

Under a $2.18M contract, energy services company Noresco installed cooling coils, a chiller, and pumps to make the power plant's combustion turbine operate more efficiently and improve power output. The project results in an estimated $200K savings annually.

5.2.4 Awareness and Energy Incentive Programs

Facilities & Services realizes that while large capital projects, energy performance contracting, and retrocommissioning can reap huge benefits for energy conservation, there is a final component of conservation that has more to do with the demand side of energy use than supply. This is the behavioral dimension. Spreading awareness of energy use, conservation, and cost has been an important part of the Utilities and Energy Services program for six years. The Provost established the Energy Conservation Incentive Program (ECIP) in 2013 to encourage campus energy conservation through behavioral change and building improvements. Buildings that reduce their energy use by the greatest percentage over the previous year received financial awards for future facility improvement projects. The larger the energy reduction, the larger the financial award. However, beginning in FY 2020, the financial award has been discontinued under the new Budget Reform model (see Section 5.4 for details). In FY20, the ECIP program transitioned to include both campus-funded and auxiliary buildings, and awarded the top performers with recognition and an award plaque. Additionally, freshmen students in the Illinois Solar Decathlon Concept Team are now producing Building-Level Energy Report Cards for all ECIP winners, to assist with spreading awareness of their accomplishments. The students will also suggest future conservation opportunities for the ECIP winners.

Each year, eight campus buildings received ECIP awards in two separate categories: occupant action and energy advancement, which reflects energy conserving building improvements. All state-supported campus buildings over 10,000 GSF are automatically enrolled in the program, and winning does not disqualify buildings from future ECIP awards. In Phase I of the program, from 2013 to 2018, award recipients have saved 268,183 MMBTUs of energy used by their buildings, a reduction of 30.4%, and collectively saved the university $1.6M.

5.3 Energy System Metering and Controls Infrastructure

5.3.1 Building Automation Systems

There is approximately $8M in obsolete building automation system (BAS) controls on campus (both departmental and facilities). Utilizing Replace and Repair (RR) funds, UES has typically implemented $500K a year in Direct Digital Control upgrades. This is expected to continue, and Table 5 shows the planned work from 2019 to 2023. The plan is to utilize the Energy Management Services group's crafts and trades as well as service contracts to implement the control upgrade projects.

Table 5. Five Year Control Upgrade Plan.

5 Year Control Upgrade Plan			
Building	Project Description	Estimated Cost	Projected Replacement year
B46 Henry Admin Phase 1	Network 8000 Replacement	$150,000	2019
B24 Newmark Phase 1	Network 8000 Replacement	$175,000	2019
B339 Temple Buell	Network 8000 Replacement	$330,000	2019
B46 Henry Admin Phase 2	Network 8000 Replacement	$200,000	2020
B24 Newmark Phase 2	Network 8000 Replacement	$225,000	2020
B29 MEL	Network 8000 Replacement	$400,000	2021
B158 Bevier Hall	Network 8000 Replacement	$300,000	2022
B210 DCL	Network 8000 Replacement	$350,000	2022
B237 Microeletronics	Network 8000 Replacement	$400,000	2023

5.3.2 VFD Replacements

There is approximately $2M in obsolete VFDs on campus. EMS RR funds were used to implement $200K a year on upgrades.

5.3.3 Deferred Maintenance

For several decades, the university has operated in a reactive mode when it comes to building maintenance. A reactive maintenance strategy has an adverse effect on the building equipment since the limited funds and resources are utilized on emergency work and not on preventative maintenance. When equipment is not properly maintained, it has a shortened life span which increases the deferred maintenance backlog across campus.

A proactive maintenance program improves safety, reduces downtime, increases labor efficiency, lowers deferred maintenance by extending equipment life, and reduces overall maintenance costs. The Utilities and Energy Services group has implemented several programs, procedural changes, and work flow practices with measurable goals to shift the department's reactive maintenance strategy to a more proactive/preventive maintenance program (see Figures 6 through 8). These figures clearly show that the transition to preventive maintenance programs has a direct result of lower costs and faster service.

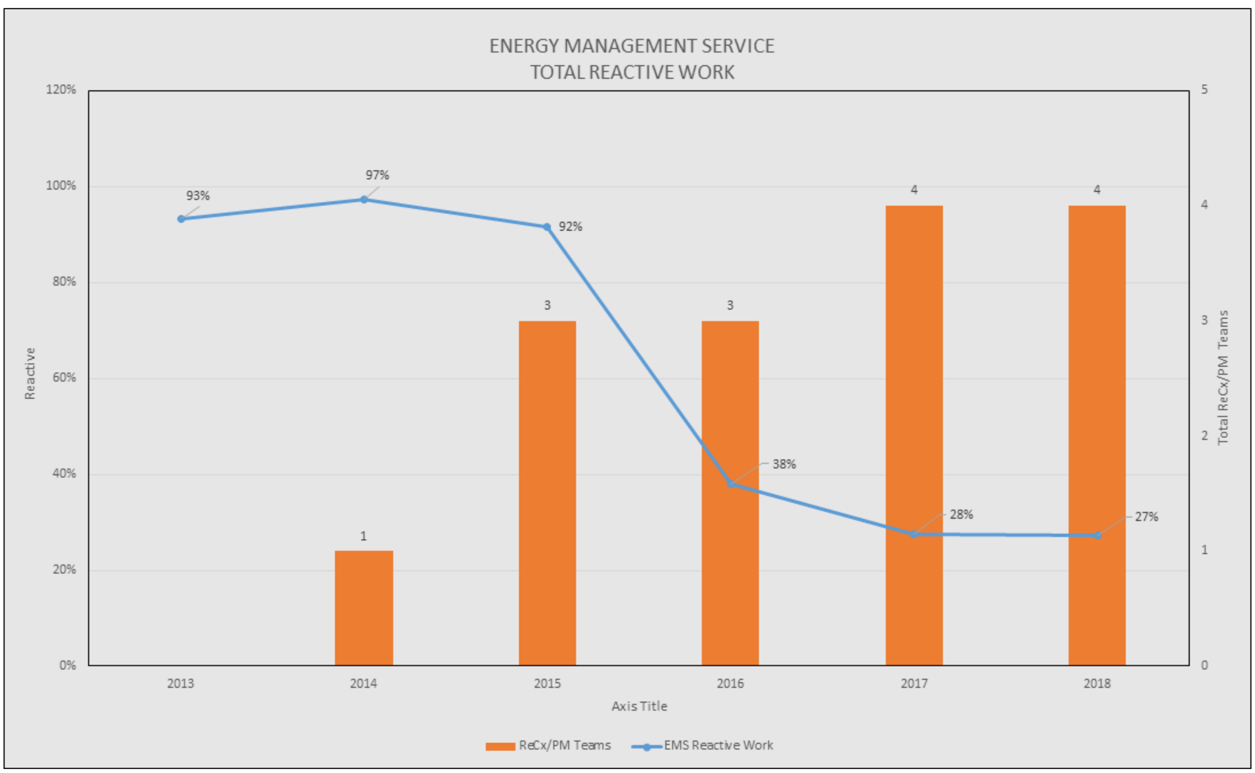


Figure 6. Total Reactive Work for Temperature Control (Shop 41) and Direct Digital Control Electricians (Shop 55)

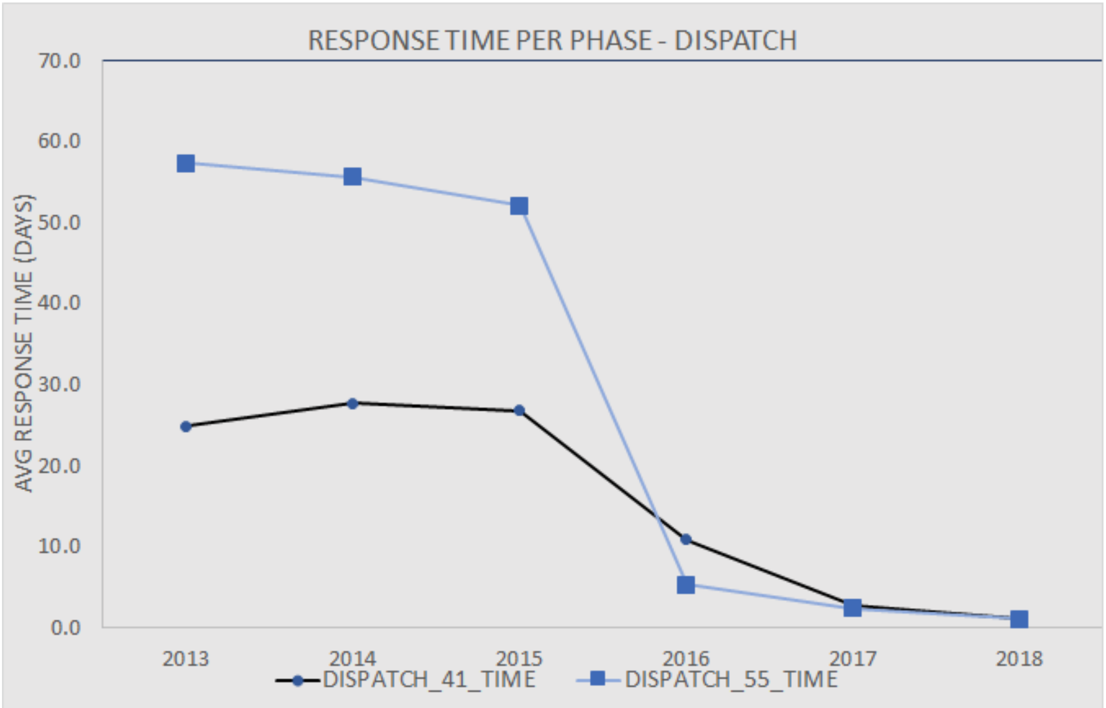


Figure 7. Response Time per Phase – Dispatch Work Orders for Temperature Control (Shop 41) and Direct Digital Control Electricians (Shop 55)

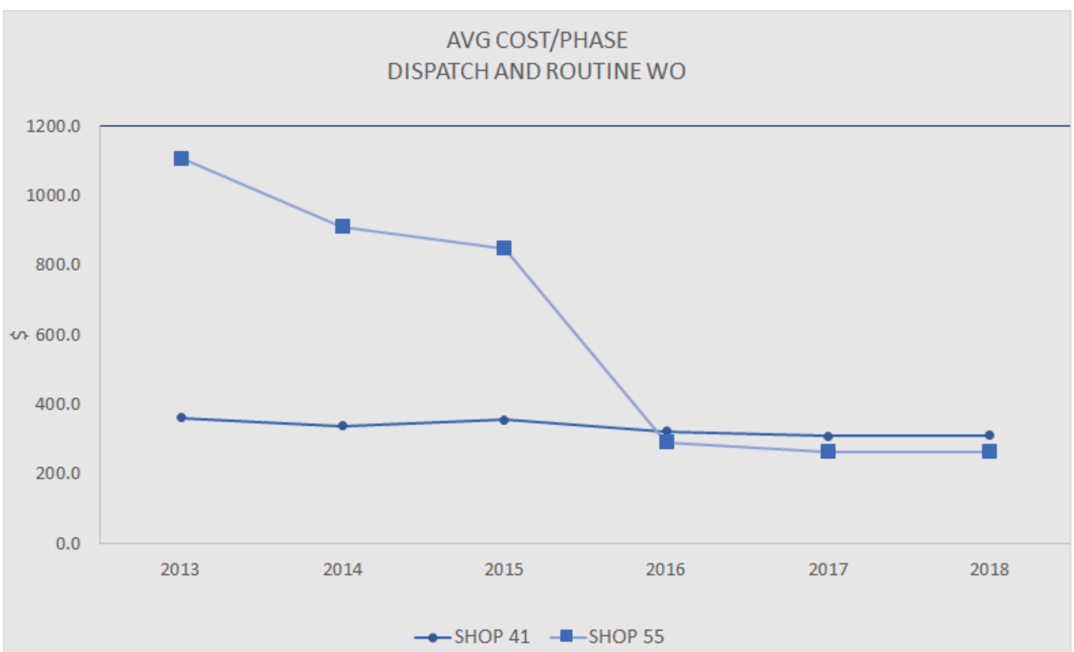


Figure 8. Average Cost per Phase – Dispatch and Routine Work Orders for Temperature Control (Shop 41) and Direct Digital Control Electricians (Shop 55)

5.4 Budget Reform

In 2015, the campus formed a committee charged with evaluating our method of allocating budget funds to campus units. This committee has designed and implemented a budget plan called Integrated and Value-Centered Budgeting (IVCB). Beginning July 1, 2019, the new budget plan revamps the way budgets are allocated and takes into consideration the department's use of space and consumption of utilities against a baseline. Thus, colleges and departments who conserve energy are incentivized by saving a portion of their budget allocation, which is then used for other programs. Since the departments will receive feedback and benefit from conservation, the Office of the Provost decided that the monetary award portion of the Energy Conservation Incentive Program was no longer relevant and can be reduced in scope to award only recognition for excellent performance. F&S will continue to support the new IVCB plan by providing data to the budget officers reflecting their performance against their baseline and enabling discussions with departments on how to reduce consumption further.

6.0 COMPLIANCE, REGULATORY, AND RISK

6.1 Title V Clean Air Act Permit Program (CAAPP)

6.1.1 Permit Requirement

The university meets the definition of a "major source" of air emissions in 40 CFR Part 70, primarily due to emissions from Abbott Power Plant. Title V of the Clean Air Act requires that any source designated as a "major source" obtain a permit in accordance with the Clean Air Act Permit Program (CAAPP). The comparable Illinois provision that requires a CAAPP permit is found in the Illinois Environmental Protection Act (415 ILCS 5/39.5). The Illinois Environmental Protection Agency (IEPA) administers the CAAPP. Accordingly, *Illinois* is required to have a Title V permit.

6.1.2 Permit Conditions

Abbott Power Plant is operated pursuant to CAAPP Permit #95120068. This five-year operating permit contains permit conditions that are divided into the following categories:

- Standard Permit Conditions
- General Permit Conditions
- Overall Source Permit Conditions
- Unit Specific Permit Conditions

These permit conditions establish unit specific emission limits; fuel usage limits; maintenance, inspection and record-keeping requirements; semi-annual and annual monitoring and reporting of compliance with permit conditions; and annual reporting of total emissions.

6.2 Spill Prevention Control and Countermeasure (SPCC) Plan

6.2.1 Plan Requirement

In accordance with 40 CFR 112, an Spill Prevention Control and Countermeasure plan (SPCC) is required for facilities that could reasonably be expected to discharge oil in harmful quantities into navigable waters of the US and that have: (1) a total aboveground oil storage capacity of more than 1,320 gallons or an aboveground oil storage capacity of more than 660 gallons in a single tank; or (2) a total underground oil storage capacity of more than 42,000 gallons.

The SPCC plan must comply with the SPCC requirements in 40 CFR 112. The plan must be certified by a registered Professional Engineer (PE) and have full management approval. The plan must be reviewed every three years by management, and it must be revised and certified by a PE within six months of facility modifications such as installation or removal of tanks.

Abbott Power Plant is required to develop, maintain, and implement an SPCC plan because it has an aboveground oil storage capacity in excess of two million gallons, and Abbott could reasonably be expected to discharge oil in harmful quantities into the Boneyard Creek or Embarras River, either directly or through storm sewers.

An Abbott SPCC plan has been developed, approved, and certified. A significant portion of the plan is dedicated to identifying and describing oil storage facilities and spill prevention procedures at Abbott Power Plant. Annual training in spill prevention is required by law and is a key component of plan implementation.

6.3 Facility Response Plan (FRP)

6.3.1 Plan Requirement

The Abbott Power Plant is required to prepare a facility response plan (FRP) pursuant to 40 CFR 112.20 because oil storage at Abbott poses a threat of substantial harm to the environment. The FRP contains information on the type and location of spill response resources, the procedures to follow in the event of a release, and, an outline of response training exercises that must be implemented on a tri-annual basis. The United States Environmental Protection Agency (USEPA) Region V has approved the plan.

6.4 Industrial Wastewater Pretreatment

6.4.1 Industrial Wastewater Discharge Permit Requirement

An industrial user is any non-domestic source regulated under the Clean Water Act, including steam electric power plants. A Significant Industrial User (SIU) is an industrial user that discharges an average of 25,000 gallons per day or more of process wastewater to a publicly owned treatment works (POTW) (40 CFR 403.3). It is unlawful for any SIU to discharge wastewater to the Urbana & Champaign Sanitary District (UCSD) without an Industrial Wastewater Discharge Permit issued by UCSD (UCSD Ordinance 678, Article VII).

Abbott discharges approximately 279,300 gallons per day (gpd) of industrial process wastewater to UCSD. Because Abbott's discharge is greater than 25,000 gpd, the power plant is classified as a Significant Industrial User (SIU), and must maintain a discharge permit with UCSD. Abbott Power Plant is authorized to discharge industrial wastewater to UCSD (Industrial Wastewater Discharge Permit APP-2019-23). This permit is for the main plant industrial process wastewater discharge.

6.4.2 Discharge Limits and Reporting Requirements

Industrial wastewater discharge limits and reporting requirements are listed in Abbott's UCSD discharge permit. The UCSD discharge permit requires Abbott to operate a sampling station capable of gathering a 24-hour time-proportioned composite sample of industrial wastewater discharges. Abbott must continuously monitor pH and flowrate, and sample once per month for cadmium, mercury, selenium, suspended solids, and zinc. Abbott must also monitor all UCSD regulated constituents semi-annually. Abbott is responsible for collecting samples, arranging laboratory analysis and submitting results to UCSD in monthly and semiannual reports.

6.4.3 Mercury Limit

Abbott must annually (mid-June) submit a letter to UCSD requesting renewal of the adjusted mercury discharge limit of 0.003 mg/l. The ordinary permit discharge limit for mercury is 0.0005 mg/l (35 Ill. Adm. Code 307.1102). Abbott is subject to an adjusted limit of 0.003 mg/l provided that Abbott: (1) does not use mercury in any plant process; (2) provides the best degree of treatment consistent with technological feasibility, economic reasonableness, and sound engineering judgment; and (3) maintains an inspection and maintenance program that is likely to reduce or prevent an increase in the level of mercury discharges.

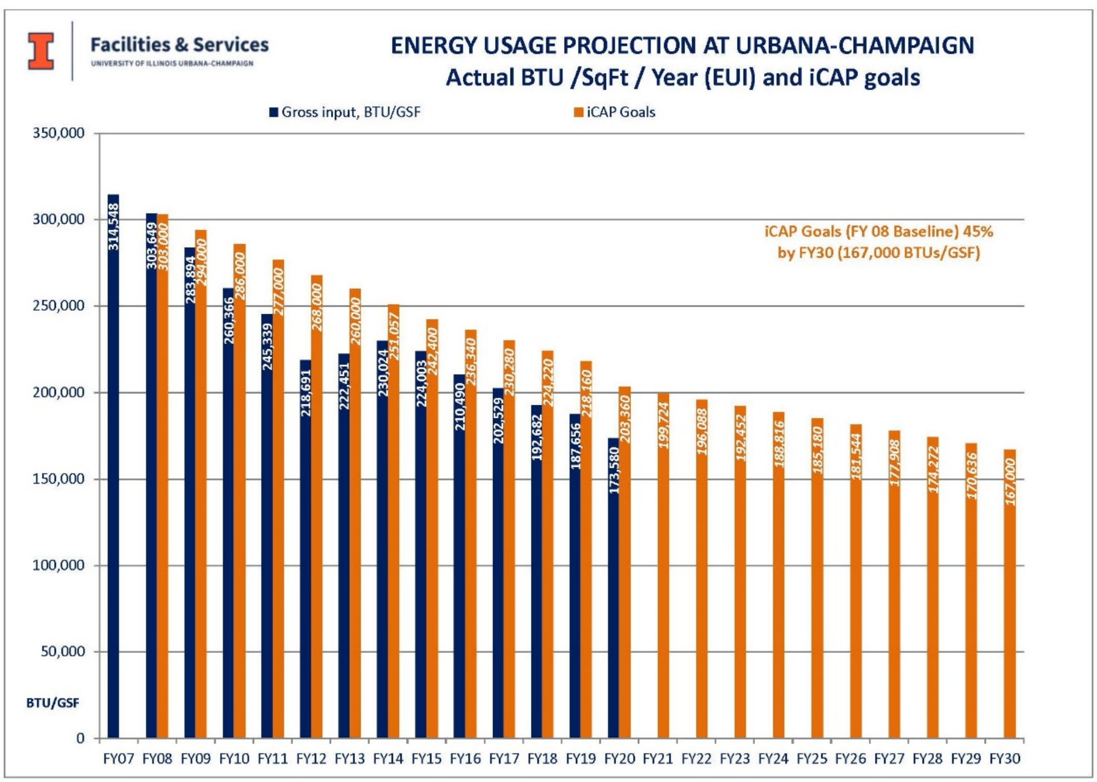
7.0 ENERGY MANAGEMENT – COMPREHENSIVE PLAN

7.1 Building Energy Reduction Goals

7.1.1 iCAP 2020 Update

The iCAP 2020 update was approved by Chancellor Jones in October 2020. Highlighted items include more collaboration with deferred maintenance and major renovation/capital projects which will improve energy efficiency. Control of Campus Space is also a major item that affects both utility infrastructure costs and energy procurement costs. We are now working towards the iCAP Goal of 45% EUI reduction by 2030 (Figure 9) and our results are ahead of schedule. Maintaining the improvements of completed buildings and providing further reductions continues to become more difficult, but the goals will be accomplished if we keep the individual initiatives on track. The Energy Utilization Index (EUI) is calculated by including all energy inputs to campus (purchased electricity, natural gas, coal, and fuel oil), with the exception of Petascale, divided by the total GSF of buildings served (22.4M GSF as of FY2020) . *Illinois* continues its efforts to improve efficiency throughout the overall energy cycle including generation/production, distribution, and utilization within the campus buildings.

Figure 9. Actual BTU/Sq.Ft/Year (EUI) iCAP goals through Fiscal Year 2030.



7.2 Demand Side Energy Conservation Initiatives

7.2.1 Operations and Maintenance of Energy Building Systems

7.2.1.1 Planned Comprehensive Maintenance

F&S has moved from reactive maintenance to planned comprehensive maintenance on critical items for building energy systems. The work of the F&S service mechanics in composite crews dedicated to evaluating and correcting existing energy system building infrastructure is imperative to continue the positive results of our energy conservation initiatives. This includes corrective work of existing equipment and/or upgrade of obsolete controls to newer more efficient and adaptable systems.

The results of this initiative clearly shows the benefits in reduced overall maintenance costs of a comprehensive approach. The composite crews can set up in a building and repair/calibrate all components systematically. It is obvious that this approach is much more efficient than continuously sending mechanics from building to building on hot/cold calls for a temporary fix of individual issues. This work not only saves energy and maintenance costs, it improves the building environment for the occupants and reduces the backlog of deferred maintenance.

7.2.1.2 Continuous Retrocommissioning (RCx)

F&S will continue with retrocommissioning and we expect to analyze and commission 500,000 SF each year with energy savings to be between 9,382 MMBTUs and 23,457 MMBTUs per year, depending on what is found. This amounts to 10% to 25% of the energy consumption in buildings visited. It will also include additional resources to assist our customers.

- Encourage Housing and Athletics (auxiliary units) to do more RCx projects
- Assist and/or follow new construction projects and/or assist in development of new projects
- Assist with space management conversations
- Assist with fume hood management ask departments to “mothball” and/or manage fume hoods usage where possible
- Continue RCx work and funding levels
- Continue to monitor past RCx buildings so that energy savings levels can be maintained

Table 6. 5 Year Retro Commissioning (RCx) Plan

5 Year Retrocommissioning (RCx) Plan							
Fiscal Year	Building	Project Description	Building GSF	FY20 Energy Costs	Expected % Reductions	Expected MMBTU reduction	Estimated Savings
FY21	Turner Hall	ESCO planning, controls upgrade	180003	$721,130	8%	2838	$57,690.40
	Bielfeldt Athletic Administration Building (Aux)	controls upgrade needed	40084	$131,055	25%	2578	$32,763.75
FY22	State Farm Center (Aux)		315821	$903,516	20%	9296	$180,703.20
	Freer Hall * (Energy usage to be determined- remodeling)	pool area remodeled.	93890	$400,000	20%	2073	$80,000.00
	Pennsylvania Avenue Residence hall (Aux)		266601	$897,788	15%	5982	$134,668.20
FY23	Wohlers Hall		99551	$310,825	10%	1489	$31,082.50
	Architecture Building		73845	$102,815	20%	964	$20,563.00
	Irwin Doctoral Study Hall		15024	$33,816	20%	1599	$6,763.20
	Football Performance Center (Aux)		124360	$150,025	20%	1694	$30,005.00
	Irwin Indoor Football Practice Facility (Aux)	controls upgrade needed	75931	$176,615	15%	1199	$26,492.25
	Wassaja (Aux)		155256	$180,113	15%	1288	$27,016.95
	Bousfield (Aux)		186114	$272,831	20%	2649	$54,566.20
FY24	Illinois Residence Hall * (Aux)	Major dining hall expansion 2020	297237	$622,979	20%	1600	$124,595.80
	Mechanical Engineering Bldg. * (renovated)	mostly renovated bldg	100518	$600,000	15%	4500	$90,000.00
	Florida Avenue Residence Hall (Aux)		314290	$1,455,162	15%	11284	$218,274.30
	Atkins Tennis Center (Aux)		68812	$84,060	15%	985	$12,609.00
FY25	Lincoln Avenue Residence Hall (Aux)		150039	$276,301	15%	1960	$41,445.15
	Enterprise Works		57256	$163,404	15%	1441	$24,510.60
	Siebel Center * (new Bldg.)	new building optimization	in progress	$150,000	15%	650	$22,500.00
FY26	Undergraduate Library (post remodel)		95906	$434,000	20%	5066	$86,800.00
	Nick Holonyak, Jr. Micro and Nanotechnology Laboratory		147347	$1,449,105	15%	12095	$217,365.75
		Totals	2,857,885	$9,515,540.00		73230	$1,520,415.25

* Energy assumptions were made at Freer, Siebel Design Center, MEB, and ISR due to recent construction projects.
Building list subject to change as necessary to support the campus mission, prioritizing the most important buildings for each fiscal year
Auxiliary building participation is included as auxiliaries comprise a significant portion of campus and their participation is considered necessary to meet iCAP goals and support SWAT Team recommendations for GHG reductions, efficiency gains, energy conservation and reduce environmental impacts. Auxiliaries would need to fund RCx work.
RCx energy savings will likely exceed expected % reductions.

7.2.1.3 Re-commissioning Teams (ReCx)

Evaluation of historic trends show that energy consumption will revert back to increases without a comprehensive plan to re-visit buildings previously improved. It is important that the campus continues with this plan as it has proved to be truly sustainable from both an energy and a financial perspective.

We plan to assemble the sixth ReCx team in FY21 to fulfill the long-range plan for this initiative. This enables us to locate a team in each of six zones on campus to revisit each building within 24 to 36 months to keep the systems tuned up and performing efficiently. The majority of ReCx teams are funded by UES base budget with a need for an additional $375,000 for the 6th team.

Without this type of program, data shows that buildings will revert back to the higher energy use and disrepair. A Return on Investment analysis was performed for recent building visits and the data indicates a simple payback of 2.4 years.

Energy savings will vary depending on the building function, size, age and the scope of the visit. The energy savings will be achieved by performing the following:

- Reviewing the buildings operating systems and ensure they are performing in the most optimal manner.
- Identify better methods for operating equipment/spaces and implementing modifications, such as:
  - Building pressurization
  - Pneumatic to Direct Digital Controls
  - Constant flow to variable air volume
  - Installation of occupancy sensors
- Implementing schedules that match actual match building usage

The energy conservation is expected to be approximately 11,259 to 15,012 MMBTU per Re-commissioning team per year. Once the sixth team is established, we estimate the total energy conservation to be from 67,556 to 90,072 MMBTUs per year for this initiative.

The buildings that have been re-commissioned show yearly EMS maintenance expense reduced by approximately 10-15% as well.

7.2.1.4 Re-commissioning Future Projects and Energy Reduction Goals

Table 7. 5 Year Re Commissioning (ReCx) Plan

5 Year Recommissioning (ReCx) Plan										
Fiscal Year	Building #	Route	Building Name	Building GSF	FY20 Energy Costs	Expected % Reductions	Energy Savings MMBTUs/Yr	Cost Savings/Yr (Based on FY20	Estimated Costs	Estimated Payback -Yrs
	24	6	Nathan M Newmark Civil Engineering Laboratory	210,939	$920,295	9.6%	5,005	$88,619	$300,000	3.39
	76	5	Psychology Laboratory	154,144	$840,267	10.4%	5,253	$87,660	$300,000	3.42
	29	5	Mechanical Engineering Laboratory	146,809	$390,834	13.9%	3,076	$54,411	$250,000	4.59
	17	6	Advanced Computation Building	45,345	$722,502	7.5%	3,225	$54,382	$150,000	2.76
	124	3	Soybean	84,700	$788,497	7.7%	3,550	$60,362	$200,000	3.31
FY21	1071	3	Early Childhood	21,100	$74,301	17.4%	744	$12,957	$80,000	6.17
	94	2	Alice Campbell Alumni Center	67,411	$145,742	11.3%	930	$16,446	$100,000	6.08
	192	2	Medical Sciences Building	114,784	$666,858	9.9%	3,669	$66,288	$200,000	3.02
	154	1	Personnel Services Building	15,649	$43,463	10.0%	211	$4,336	$50,000	11.53
	43	4	Gregory Hall	110,043	$168,684	10.8%	1,056	$18,179	$100,000	5.50
	11 & 55	2	Ceramics Kiln House/Ceramics Building	69,712	$160,961	11.3%	1,056	$18,179	$90,000	4.95
	46	5	David Dodds Henry Administration Building	156,163	$463,188	12.8%	3,448	$59,390	$200,000	3.37
	339	4	Temple Hoyne Buell Hall	94,842	$238,994	14.4%	1,962	$34,401	$150,000	4.36
	34	5	Material Science and Engineering Building	100,167	$359,946	11.7%	2,462	$42,224	$150,000	3.55
	4	4	Harding Band Building	27,837	$68,178	5.8%	230	$3,940	$50,000	12.69
	209	5	Speech and Hearing Science	30,191	$46,146	32.3%	714	$14,887	$50,000	3.36
FY22	138	2	Burrill Hall	171,832	$1,171,045	8.5%	5,804	$99,488	$250,000	2.51
	242	2	Morrill Hall	170,679	$1,101,525	9.1%	5,870	$99,760	$250,000	2.51
	75	1	Children's Research Center	46,805	$52,743	9.8%	503	$5,158	$50,000	9.69
	6	4	Armory	253,442	$322,333	9.9%	1,866	$31,919	$100,000	3.13
	54	4	David Kinley Hall	80,616	$163,270	9.0%	850	$14,720	$50,000	3.40
	60	3	Smith Music Hall	77,259	$224,623	10.3%	1,380	$23,139	$100,000	4.32
	324	6	Grainger Engineering Library Information Center	142,405	$386,045	9.1%	2,052	$34,995	$100,000	2.86
	165	3	Animal Sciences Lab	125,500	$466,383	8.5%	2,274	$39,648	$150,000	3.78
	1241	2	Gregory Place II	37,200	$231,778	7.9%	1,025	$18,350	$50,000	2.72
	206	1	Illinois Sustainable Technology Center	53,345	$207,334	7.6%	1,754	$15,670	$75,000	4.79
	376	6	Campbell Hall	35,408	$146,985	7.5%	1,010	$11,080	$50,000	4.51
	198	1	Physical Plant Service Building	160,772	$402,625	8.5%	1,956	$34,415	$100,000	2.91
	Complex	1	Water Survey	72,832	$207,231	8.7%	1,011	$18,100	$75,000	4.14
FY23	42	2	Transportation Building	52,438	$197,991	9.3%	1,043	$18,381	$100,000	5.44
	1206	4	Business Instructional Facility	166,436	$308,340	9.7%	1,739	$29,991	$125,000	4.17
	336	3	Madigan Laboratory, Edward R	171,007	$1,440,846	9.5%	7,939	$137,199	$350,000	2.55
	40	4	Stock Pavilion	43,550	$140,995	14.3%	1,199	$20,227	$50,000	2.47
	58	4	Huff Hall	177,098	$295,026	8.1%	1,348	$23,756	$100,000	4.21
	108	6	COMPUTING APPLICATIONS BUILDING	42,385	$124,205	8.3%	602	$10,358	$50,000	4.83
	13	5	Talbot Laboratory	112,547	$323,129	8.2%	1,486	$26,459	$100,000	3.78
	27	5	Lincoln Hall	177,155	$245,274	12.5%	1,795	$30,636	$150,000	4.90
	331	5	Library Information Sciences Building	51,375	$143,126	10.5%	892	$15,044	$100,000	6.65
	369	5	International Studies Building	24,473	$50,792	9.7%	537	$4,947	$50,000	10.11
	39	3	Music Building	105,343	$343,542	8.8%	1,797	$30,060	$150,000	4.99
	66	6	Seitz Material Research Lab	124,261	$772,168	7.4%	3,137	$56,879	$200,000	3.52
FY24	67	6	Loomis Laboratory of Physics	183,191	$425,465	7.9%	1,888	$33,479	$200,000	5.97
	95	6	Superconductivity Center	33,915	$159,474	8.6%	774	$13,695	$75,000	5.48
	116	2	Roger Adams Laboratory	271,196	$2,195,524	6.9%	8,793	$151,776	$300,000	1.98
	378	2	Admissions and Records Building	32,929	$61,987	5.4%	189	$3,365	$30,000	8.92
	176	1	Rehabilitation Education Center	41,709	$113,870	7.9%	476	$9,045	$50,000	5.53
	158	3	Bevier Hall	156,770	$555,694	5.9%	1,938	$32,780	$100,000	3.05
	69	3	Mumford Hall	98,672	$147,837	12.1%	1,033	$17,885	$75,000	4.19
	193	5	Swanlund Administration Building	33,805	$42,207	8.7%	238	$3,663	$50,000	13.65
	377	3	Aces Library	74,500	$340,544	9.5%	1,839	$32,363	$100,000	3.09
	174	6	Engineering Sciences Building	107,724	$84,060	16.9%	799	$14,227	$75,000	5.27
	228	6	Beckman Institute	345,990	$1,619,038	5.1%	4,541	$82,311	$250,000	3.04
FY25	70	2	Chemical & Life Sciences Laboratory	231,316	$2,310,024	4.5%	5,779	$104,504	$300,000	2.87
	44	5	English Building	121,008	$152,203	8.9%	746	$13,604	$75,000	5.51
	106	5	Illini Union Bookstore	96,342	$212,296	8.3%	932	$17,672	$75,000	4.24
	219	4	Art and Design Building	84,429	$286,634	10.2%	1,716	$29,258	$75,000	2.56
	220	4	Krannert Art Museum	62,440	$118,113	13.0%	952	$15,389	$50,000	3.25
	172	3	Foreign Languages Building	116,758	$228,637	8.5%	1,108	$19,437	$150,000	7.72
	26	5	Altgeld Hall	82,436	$198,786	8.6%	1,001	$17,061	$75,000	4.40
TBD	321	1	Natural Resource Studies Annex	63,562	$116,679	7.1%	473	$8,340	$50,000	6.00
	1073	1	Forbes Natural History Building	65,151	$114,453	8.4%	526	$9,584	$50,000	5.22
	Complex	1	VetMed complex	515,125	$3,275,497	5.1%	9,577	$166,877	$400,000	2.40
			TOTAL				132,778	$2,283,355	$7,950,000	

*** The Five year plan is subject to change to support the campus mission, utility usage, and campus customers requests.**
***Estimated payback is a simple payback and does not incorporate rate escalation.**
***ReCx energy savings will likely exceed expected % reductions since it is based on current building conditions, utility usage, and doesn't take into account building degradation or change in space funcionality.**
***The estimated costs are subject to change based on the severity of building degradation and any building moifications from previous ReCx visit.**

7.2.2 Capital Projects

7.2.2.1 Deferred Maintenance / Facility Renewal / Major Renovation

Prioritize energy efficiency within Deferred Maintenance (DM) Projects. There are many energy intensive constant volume air handling systems which are 30+ years old, and these need to be replaced with modern systems. We are targeting pneumatic control systems with mostly room level controls that need to be upgraded to direct digital control (DDC) systems with occupancy sensors. All project renovations should implement low temperature hot water systems to not only gain efficiency and controllability but to set them up for electric source heating in the future.

The magnitude of the deferred maintenance on our campus is staggering. There are various values of the total sum, depending on the specifics of how it is measured, but it is safe to say it is close to $1 Billion. We cannot emphasize enough how significant this is for a magnitude of reasons with energy efficiency near the top of the list. These older obsolete systems which reside in the majority of our campus' older buildings need to be systematically addressed with a comprehensive plan. One of the highest returns on deferred maintenance funding is to include the potential energy cost savings if the DM Projects are executed through an Energy Performance Contract utilizing ESCOs. In addition, a building's DM Backlog should be evaluated along with the value of the occupant's program output to determine which buildings should be demolished. Demolition of inefficient space is needed to offset the addition of our new high-tech modern facilities.

7.2.2.2 New Buildings

F&S will prioritize energy efficiency and adhere to standards the require use of low temp hot water for building heating systems that allows heat source to be from electric heat pumps and similar equipment. There needs to be significant improvement of proper operation of new facilities energy systems. This should include an enhanced commissioning and verification that the building meets the anticipated performance in accordance with required energy models.

7.2.3 Energy Performance Contracting with Energy Service Companies (ESCOs)

The Energy Performance Contracting (EPC) work has shown great value in conserving energy and reducing deferred maintenance. Efforts are currently underway to pre-qualify a group of Energy Service Companies (ESCOs) to perform EPC projects for the next 10 years. The current RFP, initiated in 2010, will expire in 2020. In response to the new budget model and to better serve our campus customers, the EPC delivery model will be updated to expedite smaller scale EPC projects that don't have the complexities that a multi-million dollar EPC project may contain. These smaller scale projects are expected to be less than $2.5M and due to the expedited execution, will realize savings sooner. Long term plans have been developed for both large and small scale projects. Future projects will address 23 buildings and the campus' Central Chilled Water System at an estimated cost of $95M. The streamlined small project delivery plans to address at least 15 buildings at an estimated cost of $20M. Under the current funding philosophy, the State Utilities Budget would invest approximately $35M for all projects identified in the long term plans, leaving $60M needed to fully fund the identified projects. Possible fund sources could come from the affected campus departments, deferred maintenance, third party financing, auxiliaries, and/or other campus sources.

The EPC program has been successful in reducing both utility consumption and deferred maintenance while achieving national recognition receiving multiple ASHRAE awards for various buildings and projects. Continued investment is necessary to maintain the successful results generated by the EPC program. These projects will be a vital tool in the continued effort to further reduce both utility consumption and the deferred maintenance backlog and to increase building occupant production through an improved working environment.

Table 8. 5 Year EPC Plan

Demand Side Energy Reduction Plan						
	Initiative	Project Completion Year	Energy Savings - MMBTUs/Yr	Cost Savings/Yr (Based on FY20)	Total Cost	Estimated Payback - Yrs
7.2.3	**EPC Project: Laboratory Facilities (7 Buildings)**	**FY2024**	**78,050**	**$ 1,505,000**	**$ 40,000,000**	**27**
	Animal Sciences Laboratory		*7,400*	*$ 145,000*	*$ 7,000,000*	*48*
	Turner Hall		*11,000*	*$ 215,000*	*$ 12,000,000*	*56*
	Madigan Laboratory		*22,250*	*$ 420,000*	*$ 12,000,000*	*29*
	Institute for Genomic Biology		*13,250*	*$ 250,000*	*$ 2,500,000*	*10*
	ACES Library		*3,700*	*$ 65,000*	*$ 1,500,000*	*23*
	National Soybean Research Center		*11,250*	*$ 230,000*	*$ 3,000,000*	*13*
	Plant Sciences Laboratory		*9,200*	*$ 180,000*	*$ 2,000,000*	*11*
7.2.3	**EPC Project: Laboratory Facilities (3 Buildings)**	**FY2027**	**58,500**	**$ 1,100,000**	**$ 33,000,000**	**30**
	Burrill Hall		*23,000*	*$ 445,000*	*$ 13,000,000*	*29*
	Medical Sciences Building		*12,500*	*$ 245,000*	*$ 7,000,000*	*29*
	Morrill Hall		*23,000*	*$ 410,000*	*$ 13,000,000*	*32*
7.2.3	**EPC Project: Campus Chilled Water System**	**FY2022**	**TBD**	**TBD**	**$ 1,000,000**	**TBD**
7.2.3	**EPC Project: Grainger Engineering Library Informatio**	**FY2023**	**1,500**	**$ 20,000**	**$ 1,000,000**	**50**
7.2.3	**EPC Project: McKinley Health Center**	**FY2023**	**3,400**	**$ 60,000**	**$ 2,000,000**	**33**
7.2.3	**EPC Project: Z Building**	**FY2024**	**4,000**	**$ 42,000**	**$ 750,000**	**18**
7.2.3	**EPC Project: Meat Science Laboratory**	**FY2024**	**600**	**$ 14,000**	**$ 400,000**	**29**
7.2.3	**EPC Project: Psychology Laboratory**	**FY2025**	**9,500**	**$ 165,000**	**$ 2,500,000**	**15**
7.2.3	**EPC Project: Commercial Airport Terminal Building**	**FY2026**	**2,200**	**$ 11,000**	**$ 750,000**	**68**
7.2.3	**EPC Project: Digital Computer Laboratory**	**FY2026**	**12,000**	**$ 220,000**	**$ 2,500,000**	**11**
7.2.3	**EPC Project: Advanced Computation Building**	**FY2027**	**8,300**	**$ 160,000**	**$ 2,250,000**	**14**
7.2.3	**EPC Project: Newmark Civil Engineering Building**	**FY2028**	**9,000**	**$ 175,000**	**$ 2,500,000**	**14**
7.2.3	**EPC Project: Undergraduate Library**	**FY2028**	**6,800**	**$ 120,000**	**$ 1,750,000**	**15**
7.2.3	**EPC Project: Noyes Laboratory of Chemistry**	**FY2029**	**4,300**	**$ 76,000**	**$ 2,500,000**	**33**
7.2.3	**EPC Project: Music Building**	**FY2030**	**6,500**	**$ 115,000**	**$ 2,000,000**	**17**
7.2.3	**EPC Project: Engineering Hall**	**FY2030**	**2,600**	**$ 45,000**	**$ 800,000**	**18**
Totals:	**23 Buildings & Campus Chilled Water Distribution**	**8 Years**	**207,250**	**$3,828,000**	**$ 94,700,000**	**25**

Note: *Project completion year is dependent upon many variables including but not limited to available funds, final scope, and duration of selection process. Estimated payback is a simple payback calculation and does not incorporate rate escalation. While payback does exceed 20 years in many cases, accurate energy reductions will be identified when ESCOs provide detailed audits with calculations. It is expected the ESCOs will identify more energy savings than what has been estimated here in this summary resulting in a better payback.*

7.3 Supply Side Enhancements

7.3.1 Generation/Heating

7.3.1.1 Steam Turbine Generator 10 Control Upgrade

STG 10 was installed as part of the north plant addition in the early 2000s. The monitoring and control systems are obsolete and the electronics and instruments are no longer supported by the OEM. This is one of our most efficient steam turbine generators so reducing the downtime and outages for maintenance is essential to our most efficient operational dispatch.

The controls upgrade did not improve the efficiency of the turbine, but it is anticipated it will reduce the downtime associated with the outdated and unsupported system that it replaced. It is anticipated that runtime will be at least 10% more than it has been in the recent past following this system upgrade.

It is estimated that this 10% increase in runtime will result in steam savings of approximately 17,000 MMBtu annually, due to the energy savings associated with running a backpressure turbine as compared to a condensing turbine.

7.3.1.2 Additional Back Pressure Steam Turbine Generator

Operating Back Pressure Steam Turbine Generators is the most efficient and cost-effective method of this step of a combined cycle CHP system. The options of converting a condensing / extraction steam turbine versus a new or replacement steam turbine will be evaluated within the overall long-range plans of campus.

The master plan completed in 2015 included a recommendation to add a third backpressure steam turbine generator. This recommendation was achieved by converting STG8 from an extraction/condensing turbine to an extraction/backpressure machine. The 2015 Utility Master Plan estimated that the conversion of an existing STG from a condensing to a backpressure machine would result in $230,000 in annual savings.

It is estimated that this conversion will result in steam savings of approximately 40,000 MMBTU annually, due to the energy savings associated with running a backpressure turbine as compared to a condensing turbine.

7.3.1.3 Heat Pump/Heat Recovery Chillers and Geothermal

We now have eight buildings utilizing heat pump technology and combining the outputs of both the high pressure side (for heat) and the low pressure side (for cooling). Under this arrangement they are considered “Heat Recovery Chillers” and take advantage of adjacent systems that have a simultaneous need for heating and cooling. This enable us to provide building heating from an electric source and approximately doubles the overall efficiency when operating in this mode. We have two projects underway that is based on this in a regional concept. We also have a project underway with a geothermal ground loop. We will continue to track industry progress in development to lower costs and improve efficiency of equipment and systems and evaluate implementation on a project basis.

The installation of a heat recovery chiller (HRC) and two large hot water storage tanks at Roger Adams Lab is now operational. Integrating the hot water Thermal Energy Storage (TES) with the HRC provides additional efficiency and the ability to run for more hours. As noted above, this process is twice as efficient when compared to a conventional chiller system that rejects the waste heat. The original report from AEI that estimated the project costs and energy savings estimated that the project would require approximately 24,000 MMBTUs of electricity to run the HRC and produce approximately 24,000 MMBTUs of hot water and 16,000 MMBTUs of cooling. This results in a net energy savings of approximately 16,000 MMBTUs per year (24,000 + 16,000 – 24,000).

7.3.2 Chilled Water Cooling

7.3.2.1 Replace Obsolete Equipment

The replacement of obsolete equipment past its useful life cycle will continue to be evaluated on life cycle costs including the overall system efficiency. We are also improving existing chiller efficiency with operational changes and incorporating new technologies such as the automated tube cleaning system to keep heat transfer optimal under continuous operation.

7.3.2.2 Automated Energy Model

An automated real-time energy model to evaluate overall chilled water system efficiency is planned within the next three years. Available systems are currently being researched in order to prepare an RFP to solicit proposals.

It is anticipated that the implementation of an optimization program on the chilled water system will result in energy savings of at least 10%. The annual electric consumption of the electric chillers on campus is approximately 56M kwh/year. An optimization program that provides 10% savings would result in energy savings of approximately 5.6M kWh/year, or 19,120 MMBTUs.

7.3.2.3 Thermal Energy Storage

Energy storage continues to be a key to cost savings both in purchased fuel and power and in required infrastructure. We have successfully implemented Thermal Energy Storage (TES) as part of our Central Chilled Water System. We recently installed a smaller TES for a regional hot water project (RAL/CLSL) and are evaluating potential additional benefit shifting winter electrical loads.

An additional Stratified Chilled Water Storage Tank is planned for north campus that will further enhance our Central Chilled Water System reliability and cost effectiveness. The evaluation is in its early phases but results look promising to incorporate into our system.

Table 9. 5 Year Supply Side Plan

Supply Side Energy Reduction Plan				
	Initiative	Energy Savings - MMBTUs/Yr	Total Cost	Estimated Payback - Yrs
7.3.1.1	Steam Generator 10 Control Upgrade	17,000	$ 900,000	2.6
7.3.1.2	Add'l Backpressure Turbine	40,000	$ 2,000,000	2.5
7.3.1.3	Heat Pump technology	16,000	$ 2,000,000	6.2
7.3.2.2	Automated ChW Energy Model	19,120	$ 750,000	2.0
	TOTAL	**92,120**	**$ 5,650,000**	

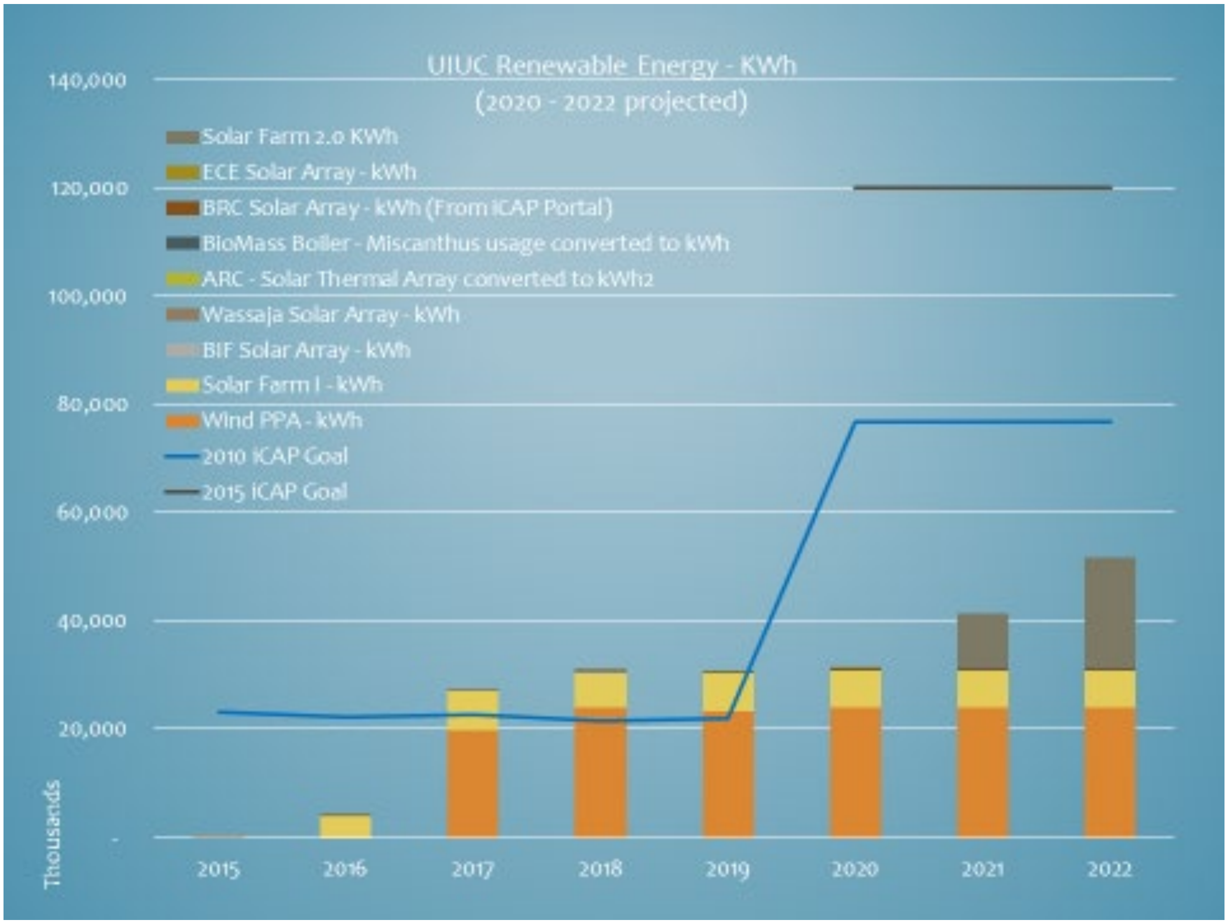
7.4 Renewable / Zero Carbon Energy

7.4.1 Renewable Energy Goals

The iCAP 2020 includes an overarching clean energy goal and two sub-objectives within the larger goal. The overarching clean energy goal in iCAP 2020 is #2.3, "Use clean energy sources for 15% of total campus energy demand by FY30." Sub-objective #2.3.1 is continued from the 2015 iCAP goal for clean power, which is to "Use at least 140,000 MWh/year of clean power (about 35% of annual power demand) by FY25." Sub-objective #2.3.2 expands the goals to include thermal energy use, with a goal of "Use at least 150,000 MMBTU/year of clean thermal energy by FY30." Additionally, UES continues to support the 2015 iCAP objective to produce at least 25,000 MWh/year from solar installations on campus property by FY25.

We are incorporating numerous renewable energy sources and continuously evaluating new initiatives to add to our portfolio. The most significant volumes of renewable energy are from the Power Purchase Agreements (PPA) that we have implemented. These PPAs allow us to procure renewable energy from a third party that can take advantage of the various tax credits / incentives that we are not eligible for. These include the existing on-site Solar Farm 1.0, the planned on-site Solar Farm 2.0 and an off-site Wind Farm that is located in Illinois.

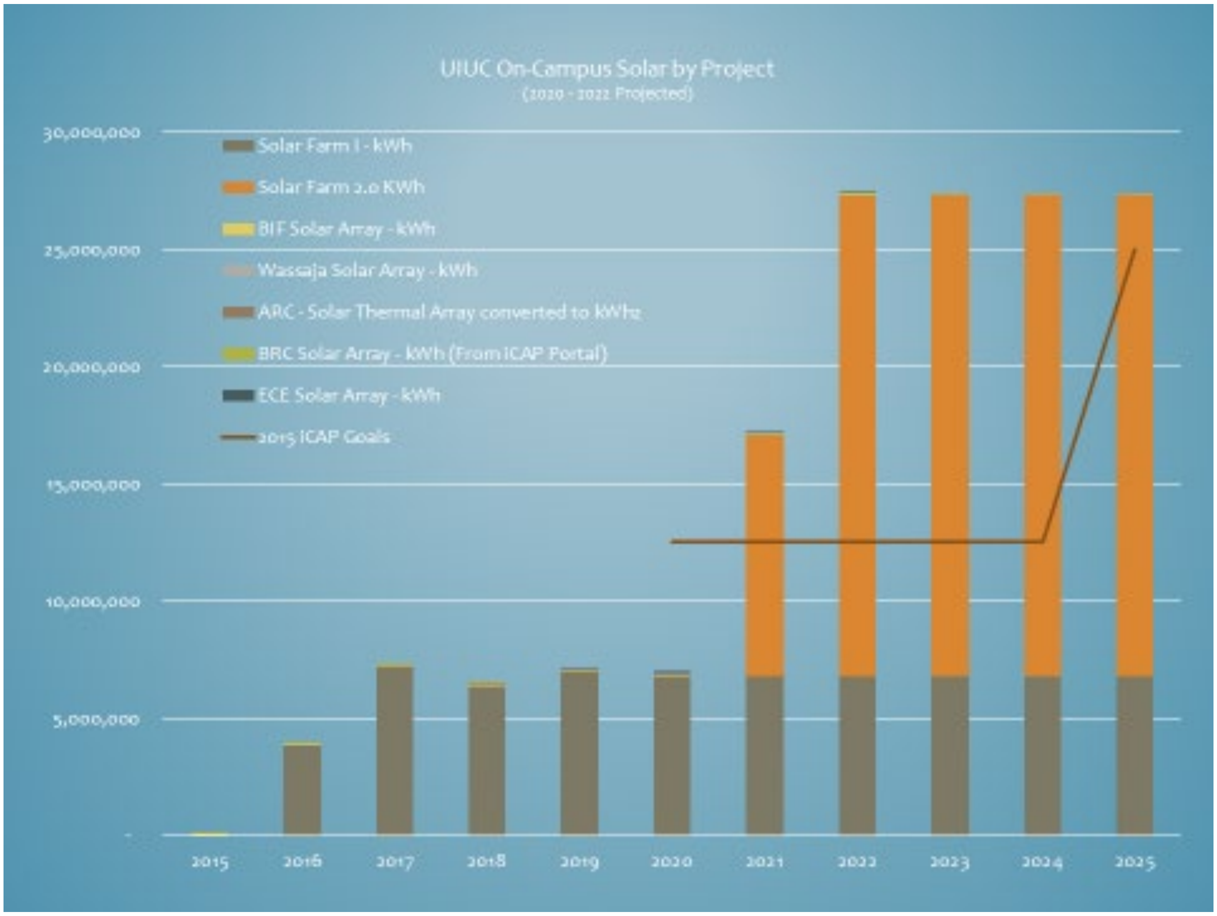
Figure 10. UIUC renewable energy - kWh.



7.4.2 On-site Solar

The 2015 iCAP included a goal to produce at least 25,000 MWh/year from solar installations on campus property by FY25. The proposed 54-acre Solar Farm 2.0 is now underway and will enable us to meet the 2025 goal ahead of schedule. Illinois has integrated a significant volume of solar energy with the addition of Solar Farm 2.0 to the original Solar Farm 1.0. The improvements in solar power efficiency at a reduced material cost allows Solar Farm 2.0 to provide power at a reduced overall cost than previous solar. Combining this with a PPA through a private entity to take advantage of the Federal Tax Credits and the on-site advantage of Behind-The-Meter Generation that avoids Transmission and Delivery and related import costs results in an annual cost that is approximately $300,000 less than the traditional purchased import power. This also results in a carbon reduction of almost 20,000 Metric Tons per year.

Figure 11. **U of I on-campus solar by project.**



7.4.3 Wind Energy

Illinois entered into a PPA for wind power in 2015 with EDP Renewables that provides us with 8.6% of the Rail Splitter Wind Farm generation. We own the power at the time it is generated for \$38/MWH but we also have to pay Transmission & Distribution and related import costs. Our share of the average annual generation results in approximately 25,000 MWH / Y, which contributes to the goal of 140,000 MWh/year from clean power sources and reduces our carbon footprint by more than 38,000 Metric Tons per year. Unfortunately, wind output is highest in winter months and evening hours, which is typically not when we need it most (hot summer days), so we intend to prioritize solar power which matches our demand profile more closely for future agreements.

7.4.4 Potential Strategies to Expand Clean Energy

The campus electrical demand is low in the winter and with the cogeneration from the required heating there are times when we do not import electricity from the grid. We have now saturated the winter demand with our renewable energy PPAs such that reduced co-generation or power export may be necessary at these times. There is limited ability to control when renewable energy sources produce electricity, and since we don't need winter power import (especially during the days when the solar farms are producing), effective energy storage would allow us to expand renewables. In order to obtain carbon neutrality, significant advancements are needed to alleviate the timing issues of existing renewable generation or development of other potential clean energy solutions. Facilities & Services' Utilities and Energy Services continues to collaborate with academic and research initiatives to advance development of potential solutions. Improvements to the supply side energy production can achieve a reduction of 5.32 tons of carbon per therm produced.

The long range plan of converting our existing building heating systems from devices that heat directly with steam to systems that use low temperature hot water is necessary to put campus in a position to better utilize renewable energy in significantly larger quantities. This hot water initiative is the method that other universities (e.g. Stanford and Ball State) have done to better utilize renewable electric energy sources.

7.4.4.1 Energy Storage

Energy storage is very significant in integrating additional renewable energy into our portfolio. We have successfully implemented Thermal Energy Storage (TES) as part of our Central Chilled Water System. We are installing a smaller hot water TES for a regional hot water project (RAL/CLSL) and evaluating potential use to shift winter electrical loads. The direct electrical storage industry has been slow to develop an economical product, but we continue to track that progress and evaluate potential uses. It will take a large-scale storage improvement in order to integrate more renewable energy into our overall energy portfolio.

7.4.4.2 Micro-Nuclear Reactor

The Utility Production and Distribution Master Plan identified small scale nuclear as a potential option for energy generation on campus. The Master Plan noted that "small-scale nuclear reactors showed promise with regards to providing reliable power with low environmental impact" but noted that these technologies were not commercially available at that time. The landscape may be changing as there are several faculty in the Nuclear, Plasma, and Radiological Engineering Department on the U of I campus that are moving forward with an effort to install a micro-nuclear reactor on our campus. F&S Utilities and Energy Services is engaged in conversations with these faculty members regarding this effort, and we intended to remain actively involved as we explore how this technology might be used to serve our campus energy needs.

7.4.4.3. Carbon Capture

There are two on-going research grant projects for carbon capture with research teams collaborating with Abbott Power Plant as a test bed for further developing this technology. These projects include both an advanced solvent-based CO_2 capture process and a novel biphasic CO_2 absorption process (BiCAP). The unique combination of our first-class multi-fuel Combined Heat and Power Plant and staff, collaborating with world class research teams at the University of Illinois, provides leading edge progress in this critical endeavor to reduce carbon emissions.

7.5 The Path Forward

7.5.1 Long Range Plan to Carbon Neutrality

Campus energy management is at the leading edge of reducing its carbon footprint by incorporating energy conservation and integrating on site solar energy generation with our state-of-the-art co-generation production but we must continue to evaluate emerging technologies as they develop. That said, a very efficient option for Campus to reach Carbon Neutrality by 2050 is by utilizing a combination of existing proven technologies. Campus needs to continue attacking its deferred maintenance backlog by aggressively converting obsolete building systems to the types that can utilize renewable electric energy. The main initiative to adapt to electric source heating is replacing the obsolete building steam preheat, perimeter, and reheat systems. There are approximately 75 major buildings that require this conversion. The budget estimate for this initiative is $150M and can be accomplished by utilizing ESCOs and Capital to eliminate this portion of deferred maintenance. It is recommended this be considered a top priority for deferred maintenance and Energy Performance Contracting. If 3 buildings per year were converted (~ $6M each) all can be accomplished by 2045. The other key initiatives are converting our existing building in efficient HVAC systems with types that meet current energy codes and updating the controls to modern technology. The HVAC and control upgrades should be done with the conversion to hot water where possible as that will be more efficient and result in a better return on those investments. These improvements are required to be positioned to obtain carbon neutrality. If we can reduce natural gas usage at Abbott Power Plant, through energy conservation efforts, we would reduce our carbon footprint by 5.318332 tons per therm.

The best solution to incorporating an efficient hot water system has begun and we are at the early stages of developing a campus wide hot water system in a similar manner to the Central Chilled Water System. This development will incorporate regional hot water plants to serve local buildings as they are converted along with the newer buildings that already utilize hot water. The regional plants will include heat pumps set up as heat recovery chillers or with geothermal as well as steam/hot water convertors and/or high efficiency HW boilers as needed for the transition. This is a long-term commitment requiring consistent funding and administrative support to accomplish.

7.5.2 Summary

Illinois is now well positioned with an effective organizational structure, robust infrastructure, and a well-established process to deliver reliable and cost-effective utility and energy service to campus in accordance with the Strategic Plan. The combined effort of the many organizations and initiatives that have contributed to the overall success of the program have worked well together. *Illinois* at Urbana-Champaign has reduced its EUI total energy consumption by 38% since the iCAP's 2008 baseline. With the projects outlined in this five-year plan and no growth in the campus square footage, we will achieve a 50% reduction from the FY08 iCAP baseline EUI by FY26! There are still many challenges and unknown future obstacles, but it is certain that the President's Energy Task Force that established a framework and plan in their 2007 report would consider the current state of utilities and energy a success in meeting that vision.

Table 10. 5 Year Combined Plan

Combined 5 Year Plan		
Plan	**Energy Savings MMBTUs/Yr**	**Cost Savings/Yr (Based on FY20)**
5 Year Retro Commissioning (RCx) Plan	73,230	$1,203,319
5 Year Re Commissioning (ReCx) Plan	132,778	$2,283,355
5 Year EPC Plan	207,250	$3,828,000
5 Year Supply Side Plan	92,120	$5,650,000
TOTAL	**505,378**	**$12,964,674**