2.

ENERGY

ACHIEVING ENERGY GENERATION, EFFICIENCY, AND CONSERVATION GOALS

The University of Illinois Urbana-Champaign main campus includes all university-owned property within the University District and on the South Farms. Last year, campus used approximately 3 trillion BTUs (or 3.2 quadrillion joules), enough to sustain 39,000 U.S. homes.[17]

Our university leads the Big Ten in overall energy efficiency, also known as Energy Use Intensity (EUI). We are proud that our energy usage per square foot is lower than average among the Big Ten according to Sightlines, LLC.[18] Nevertheless, our energy consumption remains the greatest contributor to our total GHG emissions. Energy emissions are reflected in Scope 1 and Scope 2 of our GHG inventory. In FY19, energy emissions totaled 381,069 MT-CO_2e, comprising roughly 86% of the campus's total gross emissions.[19]

The cost-saving energy efficiency and conservation projects included in the 2010 and 2015 iCAPs are cornerstones of our campus sustainability strategy.[20] We aim to further reduce energy emissions through a two-pronged approach combining proactive energy efficiency strategies with increased procurement from clean sources.

Improving space utilization is a particular challenge for the Urbana campus. In fall 2019, the university welcomed an unprecedented 50,000 new and returning students. As campus grows and evolves, we must balance the need for new facilities with the obligation to enhance our energy efficiency. While improving space utilization has historically been a critical campus issue, safety measures implemented in light of the COVID-19 pandemic have renewed interest in building usage. In his letter to unit executive officers regarding the 2020 Campus Space Survey,[21] Vice Chancellor for Academic Affairs and Provost Andreas Cangellaris remarked:

> *"The COVID-19 pandemic has caused a seismic shift in the way our Campus has had to manage our physical and human resources this year in order to safely ensure the continued delivery of our academic mission. As we transition back to campus in fall 2020, there will be many safety guidelines in place to promote social distancing and safe working conditions. In many cases, this may significantly alter how our spaces will need to be utilized in the foreseeable future."*

17 In 2015, the average American home used 77 million BTUs per year. Source: https://bit.ly/2P70Smu

18 Sightlines, LLC, is a consultant that provides facility and services data analysis to colleges and universities across the nation, including the Big Ten.

19 https://bit.ly/3hNwKZx

20 These projects are highlighted in the Energy Use Policy: https://bit.ly/39NClfJ

21 https://bit.ly/2BHmfrw

We echo the provost's emphasis on health and safety; as we look to use our space in the most sustainable manner possible, we will continue to factor in hygiene and social distancing concerns in light of the current pandemic and as a preventative measure for future scenarios.

University expansion is not the only future scenario to which we must adapt, however. Due to the social and economic consequences of COVID-19, campus must prepare to occupy not only a larger physical space, but also a smaller environmental footprint. Should the state budget for higher education contract, increased campus energy efficiency may provide a welcome avenue for cost savings. We anticipate upcoming changes in campus energy usage, with reductions in energy usage from less people on campus, and increases due to higher heating, ventilation, and air-conditioning (HVAC) demands in the fall to ventilate and circulate clean air. There will also be changes with the Petascale supercomputer energy demands, with a predicted electricity demand reduction of approximately 60,000 MWh/year, though we cannot predict the longer term usage of the supercomputer. The data figures in this chapter are based on known FY19 energy usage, which reflects a total power demand of 457,000 MWh/year. [22]

In addition to optimizing space and energy efficiency, the university is committed to pursuing clean energy and decreasing our dependence on fossil fuels. To that effect, we have been a proud member of the Environmental Protection Agency's Green Power Partnership[23] since January 2015. As a Green Power Partner, Illinois joins more than 1,500 universities, governments, business, and communities in a push toward green power.[24] As of FY19, 7.3% of the total electricity used on campus is from solar and wind energy sources (see Objective #2.3.1).[25]

Notable achievements in energy efficiency and clean energy from 2015 to 2019 include:

» Solar Farm 1.0 has been operational since Dec. 11, 2015. The 20.8-acre farm is one of the largest university solar arrays in the U.S. and generates 2% of the campus's annual electrical demand. The Solar Farm is operated by Phoenix Solar South Farms, LLC, with whom F&S holds a 10-year power purchase agreement (PPA). All power generated by Solar Farm 1.0 and all associated Renewable Energy Certificates (RECs) are owned and retired by the university.[26]

» In November 2016, the university entered into a 10-year PPA with the Illinois-based Rail Splitter Wind Farm, LLC for approximately 25,000 MWh/year through Prairieland Energy, Inc. Campus purchases the energy and the associated RECs for 8.6% of the wind farm production. We receive the power whenever the wind is blowing, which is not always aligned with the timing of our power demand. Hourly wind purchases through this PPA are reported monthly on the iCAP Portal.[27]

» After a 2017 SWATeam recommendation for expanding the solar farm was approved by the Sustainability Council, the Board of Trustees approved construction of Solar Farm 2.0 in fall 2019.[28] The 54-acre site will nearly triple the university's on-site solar energy generation, producing 20,000 MWh annually in addition to the 7,000 MWh/year from Solar Farm 1.0. Pollinator-friendly plantings will make Solar Farm 2.0 a demonstration site as a Pollinator-Friendly Solar Array.[29]

» In June 2017, a 198 kW biomass boiler was installed at the Illinois Energy Farm. This project successfully demonstrated our ability to use biomass to expand clean thermal energy use on campus.

» Geothermal energy systems are being installed at various university sites to reduce thermal energy demand from other sources. Shallow, horizontal ground loop systems have been installed at the Woody Perennial Polyculture (WPP) Research Site,[30] Allerton Park,[31] and the Gable Home at the Illinois Energy Farm. Closed-loop geothermal energy systems containing a series of 40 450-foot-deep vertical boreholes are installed at the Grainger College of Engineering Campus Instructional Facility[32] as well as at a greenhouse in the University of Illinois Research Park supporting the Realizing Increased Photosynthetic Efficiency (RIPE)[33] project. Drilled shafts constructed for the foundation of the Department of Civil and Environmental Engineering's Ven Te Chow Hydrosystems Laboratory[34] are outfitted with a closed-loop geothermal energy system.[35]

» Retrocommissioning (RCx) optimizes a building's heating, ventilation, and cooling systems and controls to maximize energy savings while maintaining occupant comfort. Since August 2007, RCx teams have updated systems in over

22 FY19 figures are based on F&S data from the March 2020 "Utility Summary FY.xlsx."

23 https://bit.ly/2BJSW7H

24 https://www.epa.gov/greenpower/what-green-power

25 The Green Power Partnership reflects power consumption, not total energy. Power on campus is only 38% of the total energy usage. It should be noted that the Green Power Partnership only includes green power purchases specifically obtained for campus, and does not include clean energy from conventional grid-purchased power.

26 https://bit.ly/2CWDlSW

27 https://bit.ly/3hQi2kz

28 https://bit.ly/31714rD

29 https://bit.ly/3hKyinh

30 https://bit.ly/2Xe2KhD

31 https://bit.ly/3geGxHZ

32 https://bit.ly/2BKxYph

33 https://ripe.illinois.edu/

34 https://bit.ly/2X8rlV6

35 https://go.illinois.edu/CampusLivingLab

80 campus buildings, reducing energy consumption by an average of 27% and avoiding $70M in utility costs for more than 10 million GSF of facilities.

» The Facilities Standards[36] exceed minimum state energy performance requirements. We require that "each proposed building construction is to achieve a minimum 25% reduction in its Performance Cost Index (PCI) as compared to its Performance Cost Index target (PCIt), while major renovations are to achieve a minimum 20% reduction."

» Centralized energy conservation efforts led by F&S (e.g., Energy Performance Contracting, RCx and Recommissioning teams, and upgraded boilers at Abbott Power Plant) have reduced campus EUI by 38.2% from FY08 to FY19. Each year, the Energy Conservation Incentive Program (ECIP) recognizes buildings with the best energy efficiency improvements.[37]

» In November 2019, the Electrical and Computer Engineering (ECE) Building achieved LEED platinum certification. Contributing factors include advances in LED and fluorescent lighting, intelligent systems to optimize energy usage, and excellent space use efficiency. The goal is to ultimately achieve net-zero energy certification.

In addition to the above achievements, the university increased energy conservation outreach efforts and behavior change campaigns in recent years. These efforts include:

» Eco-Olympics is a three-week competition that educates and motivates students to reduce residence hall energy usage. In 2019, 350 students across 17 residence halls saved 70,000 kWh of energy.[38] The competition began in 2013 and has been running annually since. Energy savings are tracked online and shared publicly during the competition.[39]

» Illini Lights Out (ILO)[40] is a student-run effort to conserve energy by switching off lights in university buildings. ILO began in spring 2016 as a pilot event organized by the Energy SWATeam. In fall 2019 alone, volunteers turned off more than 32,000 lightbulbs, saving over $8,000 in utility costs and conserving 55,000 kWh of energy.

» The University of Illinois has competed in the International Laboratory Freezer Challenge[41] since 2017, winning first prize in 2018 and 2019. This challenge encourages research-focused universities to reduce their labs' environmental impact by optimizing equipment, maximizing space, and eliminating unnecessary freezers. In 2019, 70 laboratories across 15 buildings were enrolled in the program; overall energy usage decreased by an estimated 438 kWh/day, or a combined annual equivalent of 13.5 homes' energy use for one year.[42]

» Illinois Solar Decathlon (ISD) is an interdisciplinary student organization pursuing environmental sustainability through green building, sustainable engineering, and community outreach. The award-winning Build Team has competed in U.S. Department of Energy-funded international contests for 13 years. In spring 2020, the Illinois Clean Energy Community Foundation (ICECF) awarded ISD $150K to support the team's 2020 U.S. Solar Decathlon Build Challenge entry, ADAPTHAUS, a net-zero, solar-powered home.

We are proud of our students, staff, and faculty members for spearheading the programs listed above. At the same time, we acknowledge our campus's continued need for an increased consciousness of energy efficiency and conservation.

In fall 2017, Assistant Professor of Agricultural and Consumer Economics (ACE) Erica Myers and ACE Ph.D. candidate Mateus Souza studied the impact of detailed energy reports on student energy-saving behaviors.[43] The project received funding through the Levenick iSEE Fellows Program, and ultimately determined that although similar experiments had proven effective in standard residential settings, the impact was negligible in residence halls where students do not directly pay for energy. On the other hand, simple nudges sent prior to winter break were effective in promoting the reduction of thermostat setpoints and energy consumption. Results from the study were later published in the Journal of Environmental Economics and Management.[44] Moving forward, we will continue to engage students through a combination of specialized events and behavior change campaigns.

In recent years, campus has made its first strides in the transition to renewable energy sources, such as Solar Farms 1.0 and 2.0 and the Rail Splitter Wind Farm PPA. There is, however, a long road ahead for both our campus and the world, and we plan to do our part by reducing the burning of fossil fuels and significantly expanding our use of clean energy options.

36 https://bit.ly/30ezPMw
37 https://bit.ly/3f9x100
38 https://bit.ly/2DhzEaf
39 https://ecoolympics.wixsite.com/eco-olympics
40 https://go.illinois.edu/lightsout
41 https://www.freezerchallenge.org/
42 https://bit.ly/2PbjIJm
43 https://bit.ly/3kva6Xe
44 https://bit.ly/3jXPqYn

2.1 Energy Planning Document
2.2 Increase Energy Efficiency
    2.2.1 Improve Space Utilization
    2.2.2 Reduce Building-level Energy
2.3 Clean Energy Sources
    2.3.1 140,000 MWh/year Clean Power
    2.3.2 Clean Thermal Energy

Energy Objectives

The following Energy objectives were developed by the SWATeams, iCAP Working Group, campus community, and Sustainability Council to guide the university's actions toward improved energy efficiency and clean energy procurement.

"Powering Change." Engineering students learn about energy generation through natural gas at Abbott Power Plant. Tour given by Mike Brewer.

Credit: Peter Davis, "This Learning Life" 2019 photo contest Campus Sustainability Category Winner.

2.1 [F&S] By FY24, develop a comprehensive energy planning document that includes a detailed strategy for meeting the FY50 net-zero greenhouse gas (GHG) emissions goal.

Over the last decade, the university's energy conservation accomplishments were implemented primarily through incrementalism; when opportunities arose, dedicated staff made improvements. However, this step-by-step approach is not systematic and does not guarantee the urgent changes needed at the rate required to meet our Climate Leadership Commitments. The 2015 Utilities Production and Distribution Master Plan[45] included action items for the production and distribution side of campus energy; however, it relied on carbon offsets to meet the climate commitments and it did not include a deep analysis of the overall energy conservation and efficiency needs for campus facilities. Achieving carbon neutrality for our energy needs requires significant funding, holistic conservation strategies, and clear prioritization of competing needs. We will model our communications after effective strategies implemented during the COVID-19 pandemic; for example, the university-coordinated responses, briefings, and messages through routine Massmails that brought information to the forefront. Our similar strategy will routinely communicate and disseminate sustainability information to the campus community.

F&S published an Energy Management Plan for FY21 to FY25 in summer 2020, and will lead development of a comprehensive energy planning document to keep campus energy use on track for meeting our FY50 goal. This document will provide a one-stop-shop for transparent and organized baseline statistics (e.g., building-by-building energy consumption, short- and long-term trends, etc.) made readily available to all stakeholders. At any time over the next 30 years, decision-makers can refer to these baseline metrics to gauge the university's performance and make adjustments, enabling us to avoid duplicating efforts as leaders, employees, working groups, and SWATeam members change. The document will also include comprehensive, realistic estimates for future energy supplies from solar, wind, geothermal, and other low-carbon sources such as nuclear. By performing comprehensive feasibility assessments for potential clean energy sources, the document will propose the most efficient plan to achieve our FY50 goals (e.g., land allocation, balance of energy storage/production, daily/seasonal peak attenuation, etc.).

Because the staged energy infrastructure improvements will include cost estimates allocated for design, permitting, construction, operations, and maintenance for each proposed project, the energy planning document will also serve as a financial plan. University administrators can earmark funds now for projects that will be completed one, five, 10, or 20 years in the future in order to meet our FY50 net-zero emissions goal.

Ultimately, the document will include: life cycle cost analyses to evaluate sustainable energy strategies; interim milestones to anchor progress; realistic goals for conservation, carbon emission reductions, and clean energy implementation; and a detailed funding plan with specific costs and recommendations for each strategy's anticipated funding sources.

We strive to advance our progress toward carbon neutrality with each iteration of the iCAP. Following the planning document's completion in FY24, we will use the results to inform the development of more specific iCAP 2025 Energy objectives.

2.2 [F&S] Reduce Energy Use Intensity (EUI) of university facilities from the FY08 baseline by: 45% by FY30, 50% by FY40, and 60% by FY50.

Campus EUI has decreased by 38.2% in the past decade, from 303,649 BTU/GSF in FY08 to 187,656 BTU/GSF in FY19 (Figure 2). These figures are calculated by starting with the total campus energy input (i.e., fuels purchased for Abbott Power Plant and electricity purchased from the regional grid) and subtracting energy for non-campus facilities (e.g., Willard Airport). One noteworthy exception is the National Petascale Computing Facility (Petascale), a unique grant-funded collaboration with the National Science Foundation (NSF) which is removed from the total energy consumption included in the EUI figures. This calculation produces the total campus energy use, which

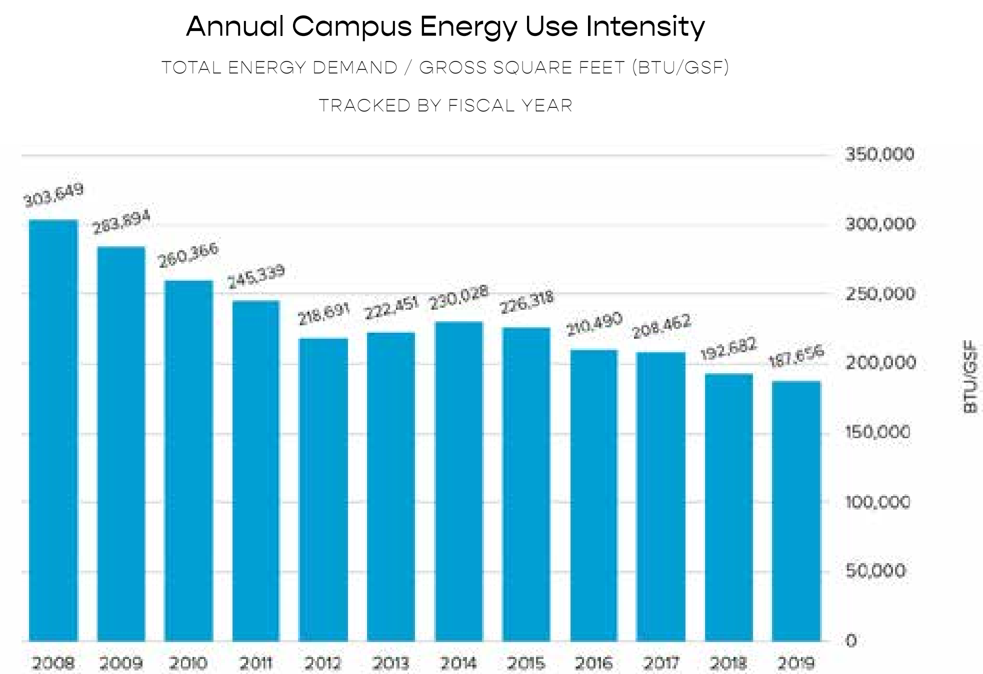

Figure 2: Annual Campus Energy Use Intensity

45 https://bit.ly/3177arK

is then normalized against the total campus square footage for the annual EUI.

Objective #2.2 continues our goals for EUI reduction into FY50 (Figure 3). Previous climate action plans targeted a 50% EUI reduction by FY50; this version increases our long-term objective to 60%. Several existing programs to reduce campus EUI are underway, and these must be continued, supported, and expanded. Specifically, we should continue implementing Retrocommissioning (RCx), Recommissioning (ReCx), Energy Performance Contracting, and the LED Campus commitment (see "Relationship to Other Commitments" in the Introduction).

To leverage the full extent of our resources toward EUI reduction, we must strengthen additional centralized energy efficiency programs. Several of these solutions are expanded upon in the following paragraphs.

CONTINUATION OF MAJOR ENERGY CONSERVATION INITIATIVES

F&S manages several successful energy conservation initiatives. These include RCx, ReCx, Energy Performance Contracting, and the LED Campus commitment. These are the most effective means of reducing energy consumption in campus buildings. The following ideas are options for expanding the impact of these major initiatives.

» Expand RCx efforts in auxiliary buildings including University Housing, Campus Recreation, and Division of Intercollegiate Athletics (DIA) facilities. Budget policies currently limit RCx efforts at F&S to state-supported facilities; the few auxiliary facilities that have separately funded an RCx project prove that there is great opportunity to improve.

» Increase funding for deferred maintenance projects and prioritize projects with an energy efficiency component. Insufficient deferred maintenance funding often results in increased reactive maintenance (i.e., temporary fixes) rather than cost-effective, preventive solutions (e.g., systematic renovation and renewal programs to upgrade facilities).

» Allocate campus funds to directly launch additional Energy Performance Contracts and grow the RCx and ReCx programs. ReCx teams were created to revisit retrocommissioned buildings every five years to ensure that buildings continue to run at top efficiency and that the systems and controls are calibrated appropriately. It is anticipated that six ReCx teams would be able to maintain the energy efficiency of major campus buildings through preventative maintenance on a five-year cycle.

ENERGY CODES AND ENERGY COST BUDGETS

The Facilities Standards[46] require that new buildings constructed on campus meet strong energy performance standards and are LEED Silver certified at minimum. (Figure 4 provides a yearly overview of LEED-certified campus square footage.) For new campus and auxiliary buildings, major retrofits requiring energy code compliance, and buildings in the design phase, project teams will be required to provide electronic input files for Energy Cost Budget (ECB) and energy performance modeling using conventional programs. F&S holds the Professional Service Consultants (PSC) responsible for meeting the required deliverables, including quality, quantity, and timeliness. To hold the PSCs accountable for meeting energy codes, F&S intends to complete PSC evaluations on all projects, including evaluations of sub-consultants. Ensuring energy code compliance will necessitate proper staffing levels for the F&S Capital Programs, Design Review, and Commissioning and Inspection departments.

Using information gathered from capital projects, faculty members and researchers can collaborate with F&S to develop a reference database of calibrated energy models for campus buildings. This might be the product of student classroom projects. The campus could then use these models to prioritize building retrofits and determine the preferred level of improvements (i.e., envelope versus mechanicals) for each building.

46 https://fs.illinois.edu/resources/facilities-standards

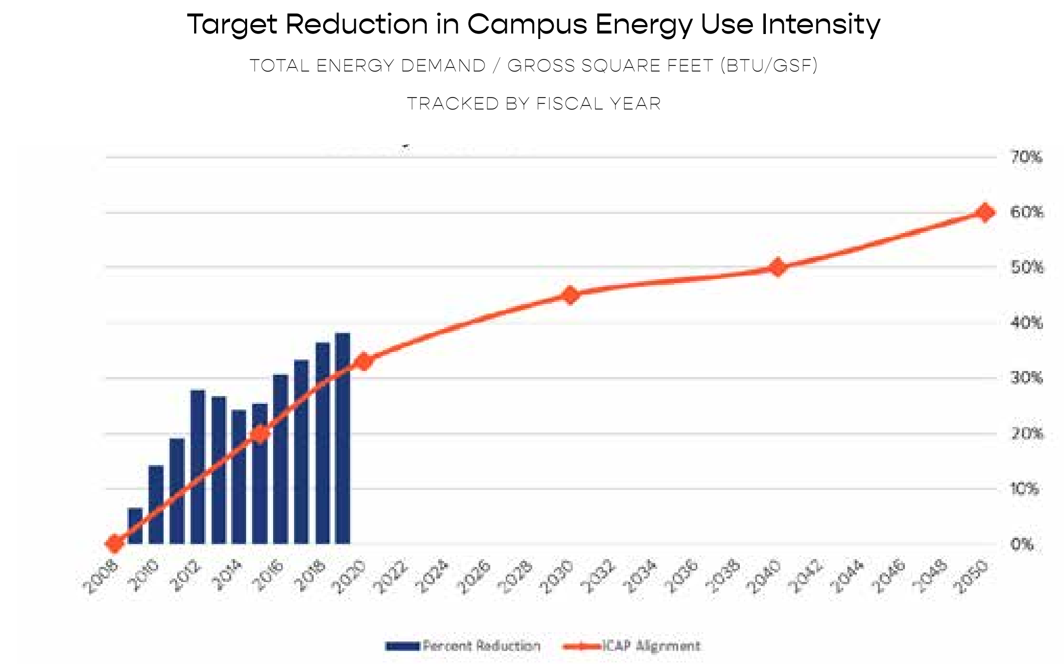

Figure 3: Target Reduction in Campus Energy Use Intensity

LEED-Certified Campus Square Footage

TRACKED BY FISCAL YEAR

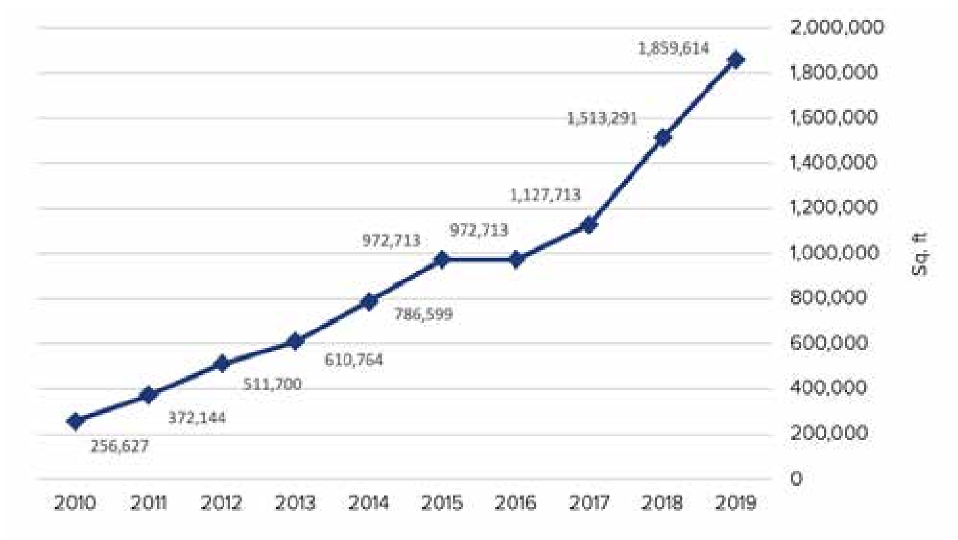

Figure 4: LEED-Certified Campus Square Footage

BUILDING ENVELOPE RETROFITS

Building envelope retrofits should be applied to more campus buildings. While progress in enhancing heating, ventilation, and air conditioning (HVAC) systems is underway, there has been little focus on building envelopes. Actionable steps in this area include developing internal campus expertise in this area and identifying viable funding sources.

F&S staff should consider Building Envelope Commissioning (BEC) and mechanical commissioning (and recommissioning if necessary) for major building projects.

REDUCE PEAK ELECTRICITY CONSUMPTION

A potential pathway toward reducing peak electricity consumption is decreasing peak demand by 20% over the next five years. Electrical demand correlates with a building's daily use, with the peak occurring when the highest volume of students, staff, and faculty members occupies the space; typically, this is roughly the middle of the day. This is illustrated by the Business Instructional Facility's (BIF) energy dashboard (Figure 5).[47] The figure reflects that on March 12 and

47 https://bit.ly/2XciUIB

Energy Dashboard Weekly Display from the Business Instructional Facility (BIF)

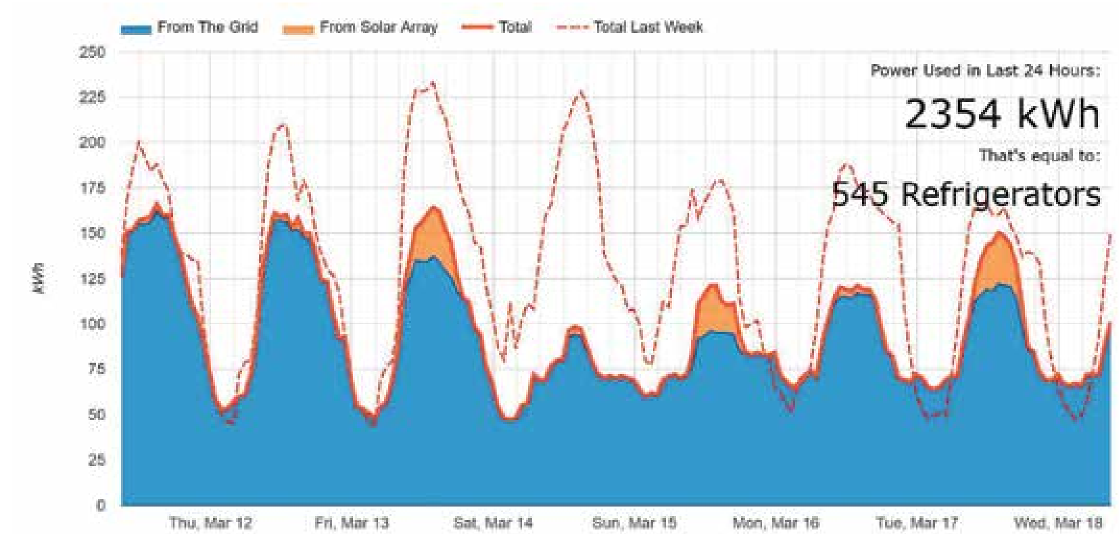

Figure 5: Energy Dashboard Weekly Display from the Business Instructional Facility (BIF)

March 13, 2020, students began leaving campus as a result of the upcoming spring break as well as preliminary course cancellations due to COVID-19. The following Saturday, Sunday, and Monday reported notably reduced electricity usage compared to the previous week (shown as a dotted line on the corresponding days). We plan to monitor how the return to campus will impact energy use to better understand energy usage and to inform long-term changes to decrease our consumption.

In FY19, campus used a total of 457.31 million kWh (457,305 MWh) of electricity (Figure 6). We can reduce the peak demand through a combination of increasing efficiency and adjusting campus schedules to flatten the peak throughout the day. COVID-19 safety protocols may require altered schedules in order to reduce building traffic; if so, we will remain mindful of how best to meet the dual demands of public health and sustainability.

2.2.1 [Provost Office] Improve efficiency of space use by minimizing the square footage per person and updating the Space Policy in the Campus Administrative Manual (CAM) by FY23.

Because building space is linked to energy demand, careful stewardship of campus square

Total Campus Electricity Usage (MWh)

TRACKED BY FISCAL YEAR

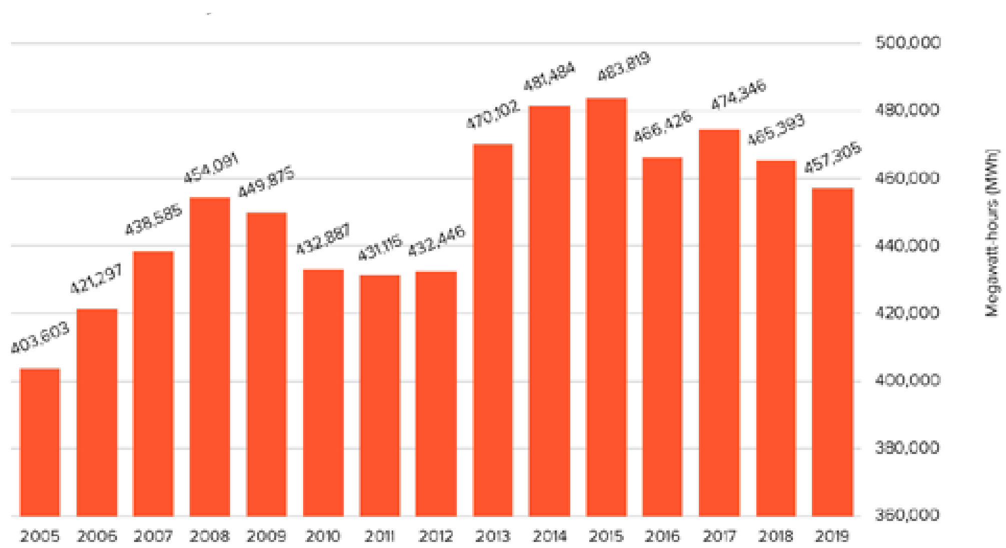

Figure 6: Total Campus Electricity Usage (MWh)

footage is a vital component of our GHG reduction strategy. Likewise, a clear understanding of the anticipated growth or reduction of building square footage is needed for developing an effective energy plan.

As reported by Sightlines, LLC, the Urbana campus has low space use efficiency compared to other universities in the Big Ten.[48] Figure 7 illustrates our campus density factor (i.e., the square footage of campus divided by the equivalent full-time users) in relation to our Big Ten peers and compared to the average across the higher education institutions Sightlines, LLC evaluates; clearly, there is room for improvement.

To improve our space use efficiency, we need to increase space utilization rates, remove outdated and unneeded spaces, and actively restrict the growth of total campus GSF.

Increasing space utilization rates can include clarifying appropriate allocation policies for various room categories and implementing innovative solutions like hot-desking (wherein workspaces are used by multiple people on a rotating basis). Removing unneeded spaces can include renovations or demolitions; the 2017

48 Sightlines ROPA+ University of Illinois Urbana-Champaign, FY18

Total Campus Density Factor in Relation to Peers

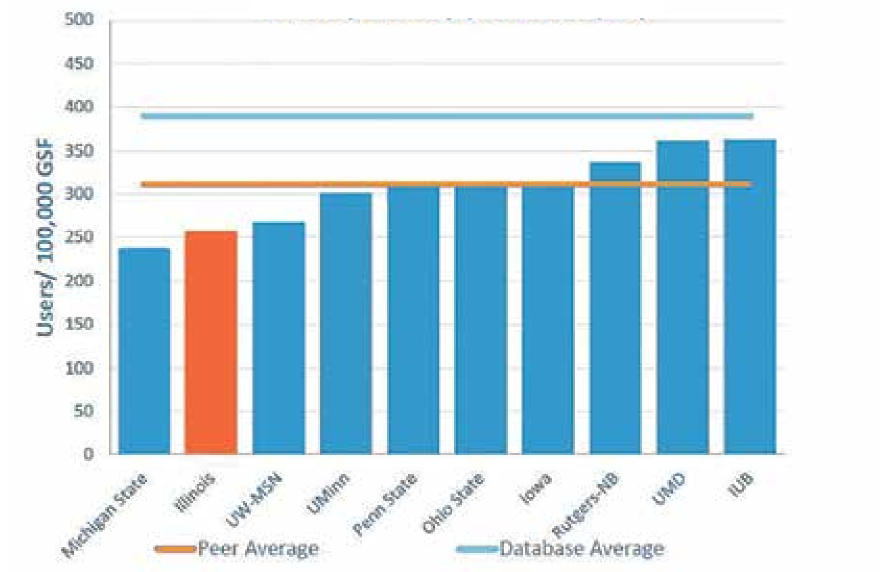

Figure 7: Total Campus Density Factor in Relation to Peers

Campus Master Plan update identified specific buildings that should be demolished. In light of current COVID-19 concerns and any threats to public health that may arise in the future, we will implement these and other space use efficiency strategies only when they fully align with campus safety protocol.

Efforts to actively restrict the growth of campus GSF began with the 2010 iCAP commitment to enact a "no net increase in space" policy. The Net Zero Space Growth policy in the CAM (FO-44)[49] was established in June 2015; since its inception, both the 2017 Campus Master Plan update and the Integrated and Value-Centered Budget (IVCB) reform have been implemented. The Campus Master Plan defined campus plans for the next 10 years, with only a 1.5% GSF increase. Concurrently, the IVCB budgeting system redirects transitioned energy and space costs from the Office of the Provost and F&S to academic colleges and administrative units.

A complete halt to campus expansion cannot be sustained indefinitely. Educating our students and researching grand challenges will, at times, require growth beyond the current GSF.

49 https://cam.illinois.edu/policies/fo-44/

Total Energy Consumption for University-owned Buildings in the University District (MMBTU)

TRACKED BY FISCAL YEAR

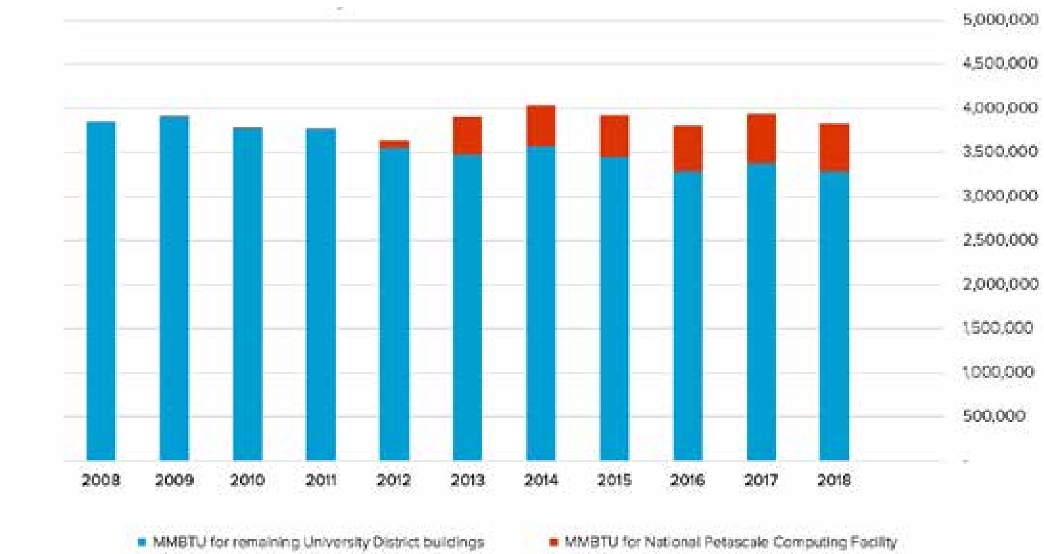

Figure 8: Total Energy Consumption for University-owned Buildings in the University District (MMBTU)

Regarding these likely increases, it is important that we keep an eye on our Climate Leadership Commitments and remain thoughtful stewards of our campus space.

Over the next few years, the Office of the Provost will work to update the CAM space policy, providing insight into how to address the tension between an inherent need to grow as an institution and the need to limit GSF. This will result in a sustainable space stewardship program that holds university administration accountable for maintaining the highest standards of space use efficiency while including a review and approval process to manage growth and reduce emissions.

2.2.2 [Units w/F&S] Reduce the total annual energy consumption of each college-level unit by at least 20% from an FY15 baseline by FY35.

In 2018, the Energy SWATeam completed an analysis of the total energy consumption of every university-owned building within the University District (north of Windsor Road) using data from the Energy Billing System between FY08 and FY18 (Figure 8).[50]

50 https://bit.ly/30c18qw

Assessment of Square Footage Changes in University-owned Buildings from FY08-FY19

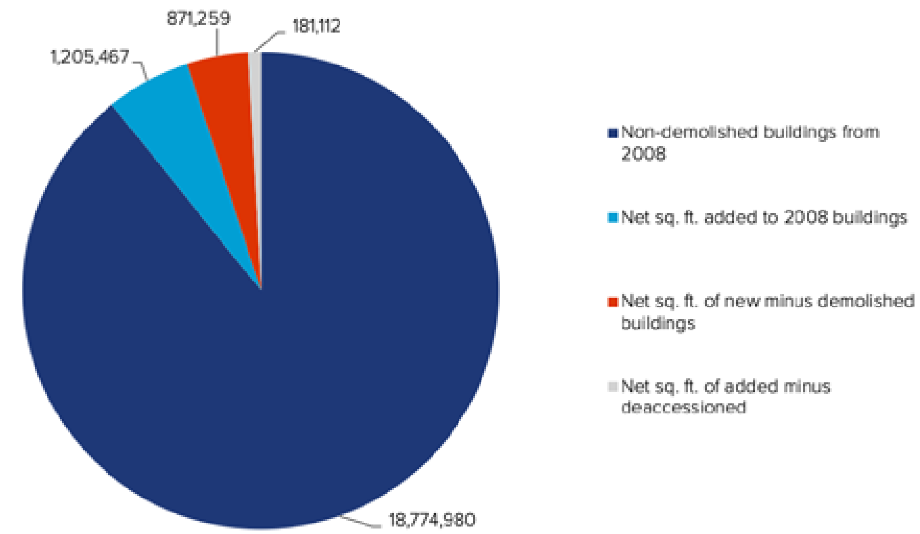

Figure 9: Assessment of Square Footage Changes in University-owned Buildings from FY08-FY19

Unfortunately, total energy consumption (when not normalized by GSF) increased by 2% in this time period. This was influenced by both an 11% increase in University District square footage (Figure 9) and by the addition of Petascale (Figure 10), which used 724,017 MMBTUs in FY19 and did not exist in FY08. According to Energy SWATeam co-chair Bill Rose:

“Energy conservation [efforts] in the last 10 years have been wondrously successful — if left on their own, the conservation goals could be easily met. Without the square footage burden and Petascale burden, it’s been really successful. But when we add the new square footage and Petascale, the total campus load is up, not down.”

F&S employees work hand in hand with facility managers to maintain and improve university-owned buildings. With the FY20 implementation of the Integrated and Value-Centered Budget, colleges are now responsible for space usage and building-level energy costs. This increases college-level incentives to improve energy efficiency in the buildings and spaces they occupy.

To achieve this objective, every university-owned building occupant needs to participate in the iCAP and endeavor to reduce energy consumption. To support this, F&S collaborated with the Illinois Solar Decathlon (ISD) Concept Team in FY20 to create building-level en-

Annual Electrical Consumption for Petascale Facility (MWh/year)

TRACKED BY FISCAL YEAR

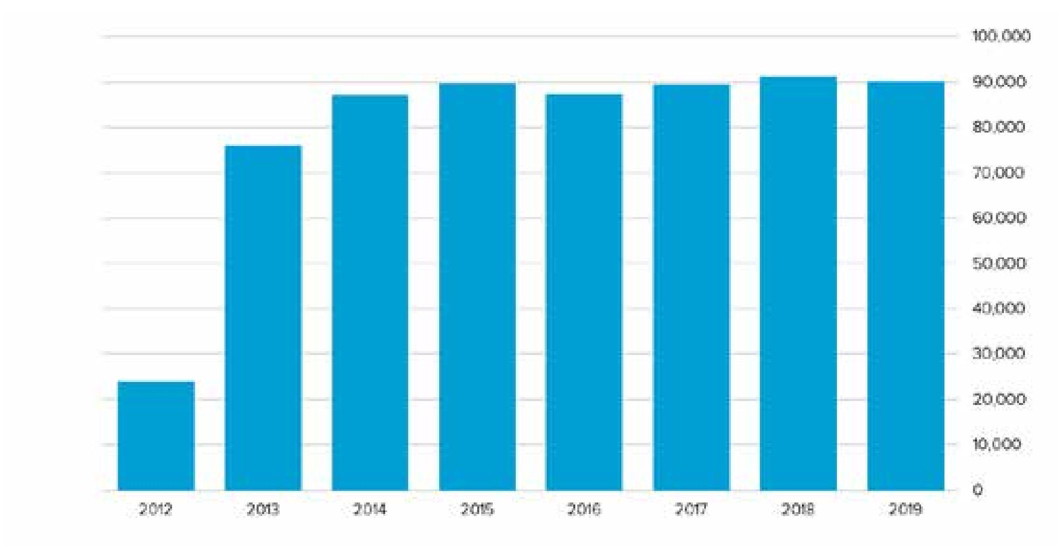

Figure 10: Annual Electrical Consumption for Petascale Facility (MWh/year)

ergy and water report cards. This process pulled available data from the Energy Billing System and evaluated total energy and water reduction since FY08 for the 56 buildings that won the Energy Conservation Incentive Program (ECIP).[51]

The next steps include working with building contacts to strategize energy efficiency solutions. F&S will connect with the facility manager, a building-level communications contact, and a related student organization to develop strategies for reducing energy consumption in individual buildings. The student representative for each building will obtain pledges from building occupants in support of energy conservation.

51 https://bit.ly/3f9x100

2.3 Use clean energy sources for 15% of total campus energy demand by FY30.

Clean energy sources can include but are not limited to: solar, wind, geothermal, biofuels, biomass, renewable natural gas, and nuclear.

The university should continue to support and encourage pursuance of grant and research opportunities in these markets as well as other clean energy technologies.

A key concept in the transition to clean energy is the difference between electricity and total energy. In FY19, electricity accounted for just 38% of total campus energy consumption; the district heating and cooling systems and certain buildings with direct natural gas connections accounted for the other 62%. Because the most prevalent clean energy technologies are electricity-generating wind and solar systems, many discussions about clean energy focus on clean power.

Since the 2010 iCAP, we have made progress to incorporate clean energy for power and thermal energy on campus, with a focus on renewable electrical power. Figure 11 outlines the clean energy used on campus in FY19.

The 32,092 MWh of clean energy represents just 2.8% of total campus energy use in FY19; however, achieving our clean power target of 140,000 MWh/year (see Objective #2.3.1) equates to 12.2%.[52] This objective's larger goal of 15% clean energy by FY30 can come from

52 The denominator is FY19 total energy use.

Clean Energy Source	MWh in FY19	Category
Wind Power Purchase Agreement	24,726	power
Solar Farm 1.0 Power Purchase Agreement	7,026	power
Business Instructional Facility Rooftop Solar	40	power
Wassaja Residence Hall Rooftop Solar	41	power
Building Research Council Ground-mount Solar	21	power
Activities Recreation Center Solar Thermal	3	thermal
Energy Farm Biomass Boiler	235	thermal
Total Clean Energy in FY19	**32,092**	**total**

Figure 11: Clean Energy Used on Campus in FY19

any qualifying source, including but not limited to an anaerobic digester, thermal storage, fuel cells, batteries, and nuclear.

With more than 250 campus buildings using steam heat, we cannot focus our efforts exclusively on clean power; we must incorporate clean thermal energy as well. A 198 kW Heizomat biomass boiler was installed at the Illinois Energy Farm in June 2017 under iSEE leadership.[53] This project was supported by the Illinois Clean Energy Community Foundation (ICECF) and the Student Sustainability Committee (SSC), with additional funding provided by the University of Illinois Dudley Smith Initiative, the Carbon Credit Sales Fund, and the Revolving Loan Fund. It is a successful demonstration of using cellulosic biomass (i.e., the Miscanthus grown for research at the Illinois Energy Farm) to heat a greenhouse, and the facility can be expanded to provide more clean energy.

The Activities and Recreation Center (ARC) features a solar thermal system which reduces the need to use thermal energy from other sources. This system produces sufficient clean thermal energy to heat the three Olympic-sized swimming pools — and all domestic hot water used — in the facility. While the existing solar thermal array is small-scale, producing only three MWh/year of clean energy, this technology is particularly viable in the central Midwest and should be considered for additional campus locations.

Several campus researchers are actively developing other clean energy solutions. For example, in collaboration with the Urbana-Champaign Sanitary District (UCSD), studies for converting food scraps to energy using the UCSD anaerobic digester are underway. Another program involves fine-tuning the process of converting used plastic waste to diesel fuel. Energy storage research is also expanding to include the potential to use geothermal technology for storage.

This objective's extended timeline allows us sufficient time to identify clean energy sources and modify Abbott Power Plant operations accordingly.

2.3.1 [F&S] Use at least 140,000 MWh/year of clean power by FY25.

As one component of Objective #2.3, campus will continue transitioning to clean energy sources for power. When calculating our total clean electricity use, we include only power that has associated Renewable Energy Certifications (REC) in our possession. Thus, the changes in the regional electrical grid,[54] sometimes referred to as "greening of the grid," do not impact our reporting of clean power consumed. This is consistent with the requirements of the EPA's Green Power Partnership reporting system and the Federal Trade Commission's Green Guides.[55]

Figure 12 illustrates the sources for all electricity used on campus in FY19. As shown, approximately 7.3% of our power was generated directly from clean energy sources. The total of 31,854 MWh/year of clean electricity was acquired from both on-campus solar energy (7,128 MWh) and off-campus wind energy (24,726 MWh). Completion of Solar Farm 2.0 will increase campus clean energy usage to more than 50,000 MWh/year, which will surpass 10% of our existing power demand. This is excellent progress.

To continue building on these successes, we have set the goal to use 140,000 MWh/year of electricity from clean power sources (i.e., approximately 35% of our annual power demand) by FY25. This requires purchasing clean energy from off campus, and we have been investigating options to do so. The Energy SWATeam submitted a recommendation in May 2018 to seek an off-campus solar PPA for meeting this objective. We are hopeful that a VPPA for 90,000 MWh/year of solar power will be a viable method for achieving this objective and launching a new solar array off-campus in Illinois with clear additionality.

53 https://bit.ly/3ffpqnY

54 Campus is in egrid subregion SRMW = SERC Midwest. See https://bit.ly/31618rh

55 https://bit.ly/3fmG31f

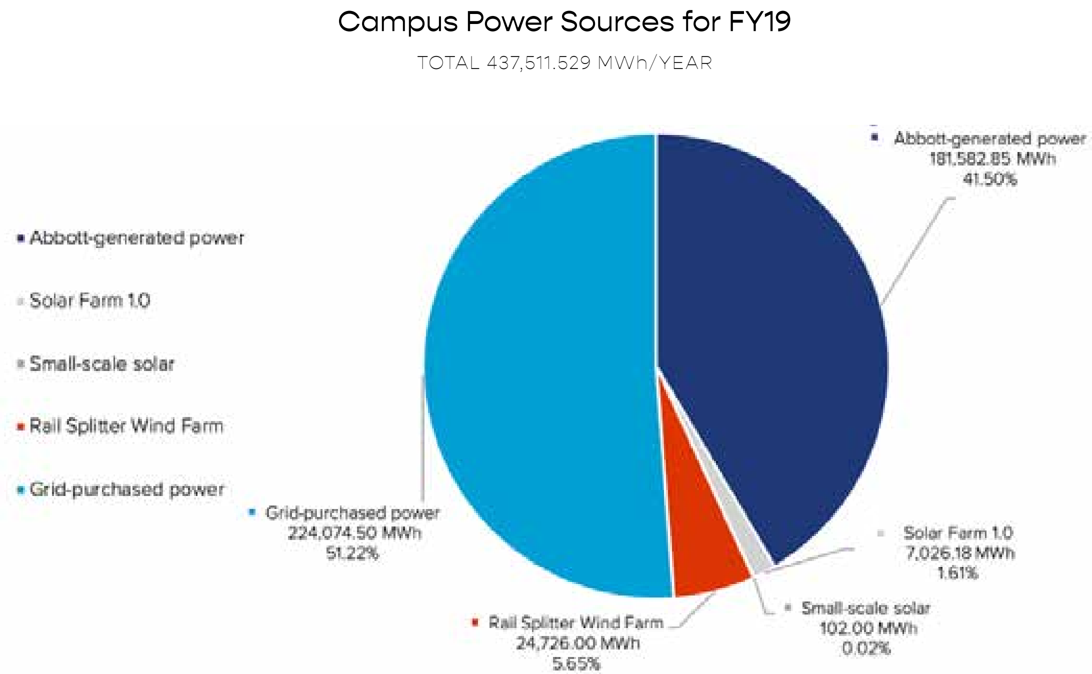

Figure 12: Campus Power Sources for FY19

2.3.2 [F&S] Use at least 150,000 MMBTU/year of clean thermal energy by FY30.

As stated in the Introduction, the university owns a best-in-class combined heat and power plant (Abbott Power Plant), a district steam heating system, a district chilled water cooling system with energy storage (the Campus Chilled Water System), and the campus electrical grid. This comprehensive network of energy processes (Figure 13) has served us well; in fact, many cities and campuses around the world are planning to implement district heating and cooling systems to increase energy efficiency.

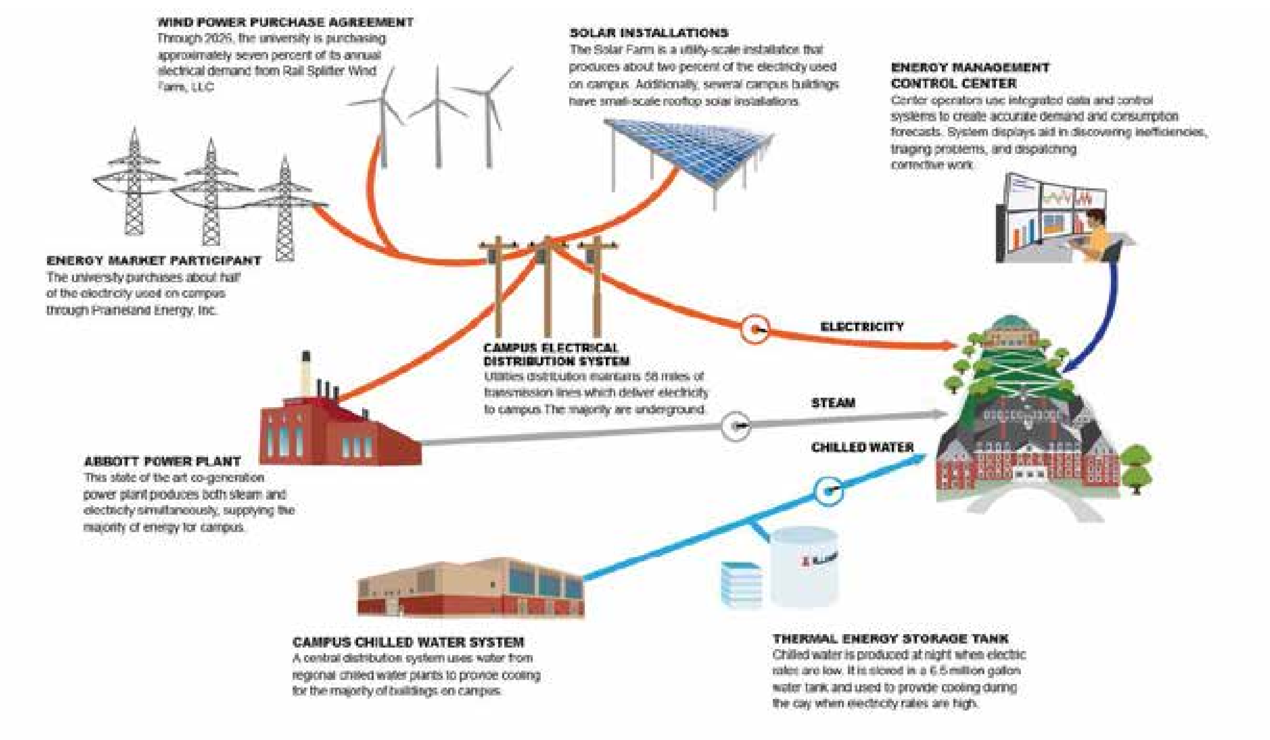

Figure 13: University of Illinois Urbana-Champaign Energy Systems

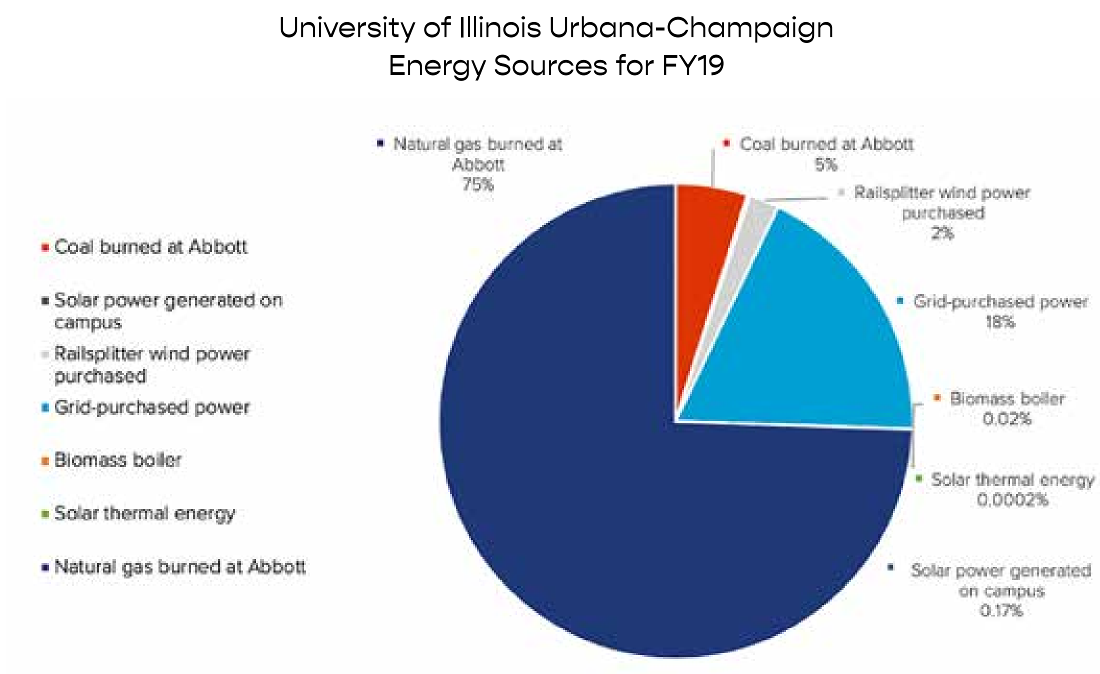

Figure 14: University of Illinois Urbana-Champaign Energy Sources for FY19

As shown in Figure 14, Abbott Power Plant generated 80% of the total campus energy in FY19 — this energy produced 41% of the electricity used on campus. Using the best available air pollution control technology, Abbott meets or exceeds all EPA emission standards. Electrostatic precipitators and a flue gas desulfurization unit (scrubber) supported by a Continuous Emission Monitoring System in the stack remove 90% of air pollutants, providing significant environmental benefits. Efficient cogeneration coupled with emission reduction equipment have decreased carbon dioxide emissions by 101,000 tons per year[56] compared to conventional electric generation and heat-only systems.

Currently, we burn natural gas and coal to produce the steam needed to heat campus through the district heating system. In keeping with our carbon neutrality goal, F&S has investigated several methods to reduce fossil fuel use at Abbott and subsequently reduce our total emissions. The 2010 iCAP included a plan to "evaluate the potential for: 1) eliminating summer coal use in the near term; 2) eliminating all coal use by 2017; and 3) alternative means of generating and distributing thermal energy (hot water distribution, regeneration, geothermal looping) in the long term."[57] The resulting study (the Utility Production and Distribution Master Plan[58]) was completed in 2015.

One major change since the FY08 baseline is the university's shift away from burning coal. The total energy generated as a result of burning coal at Abbott decreased by an impressive 89% from FY08 (1,792,464 MMBTU) to FY19 (203,954 MMBTU). Continued use of coal at Abbott helps meet the campus's heating demand during the coldest months of the year and supports research on reducing emissions from coal-fired power plants. Illinois is a national leader in the study of carbon capture and carbon storage technology, and F&S is collaborating with researchers at the Illinois Sustainable Technology Center (ISTC) to test carbon capture technology using Abbott as a living lab.[59] ISTC has also used Abbott flue gas in studies related to algal biomass and biofuels. The ability to use coal during the coldest months of the year has enabled Abbott to become nationally recognized as a living lab for research on second-generation carbon capture. F&S is collaborating with the ISTC and the

56 https://bit.ly/339SLxN

57 https://bit.ly/2XcKdm6

58 https://bit.ly/3hQDdCZ

59 https://bit.ly/39IWymW

Illinois State Geological Survey on a range of possible breakthroughs that could lead to effective carbon capture worldwide. As a utility that owns its own grid and generation capacity, campus represents an attractive testbed for cutting-edge efforts to eliminate greenhouse gases at commercial scales.

Other options for reducing emissions at Abbott include using geothermal or solar thermal to preheat water before it travels to existing coal or natural gas boilers. F&S collaborated with Illinois Business Consulting to investigate the potential for mixing woody biomass with the coal, but it was determined to be infeasible.[60]

Perhaps the best option for decarbonizing thermal energy on campus is renewable natural gas (RNG). RNG is a drop-in solution that can be generated from a variety of technologies — most notably from upgrading biogas produced from anaerobic digestion — and used in existing infrastructure such as at Abbott Power Plant. Argonne National Laboratory publishes a database of RNG projects[61] divided into the following categories: farms, food waste, landfills, wastewater treatment, and other waste. The Argonne database shows an increase of 53% from 2017 to 2019, and a total 2019 production capability of about 45 million MMBTU. This is a growing opportunity that the university will pursue for clean energy.

Another potential clean energy solution that can be implemented at Abbott is portable Advanced Small Modular Reactors. Faculty research in the Department of Nuclear, Plasma and Radiological Engineering (NPRE) supports the installation of a microreactor to produce steam at Abbott as an alternative to fossil fuels. The university's high energy demand offers opportunities for interdisciplinary research to reduce campus energy consumption, especially pertaining to steam production. The role of nuclear power in our greater energy system is still uncertain. Illinois faculty members are researching and collaborating with key stakeholders to address potential barriers and strategies to overcome uncertainties. As we work to expand clean energy sources and achieve carbon neutrality, we will continue to study the feasibility of nuclear reactor technology.

In addition to Abbott Power Plant, we are implementing alternative heating and cooling solutions in individual buildings, such as chilled-beams, heat-recovery chillers, energy recovery, and geothermal. The chilled-beam heating and cooling system is incredibly efficient in the Electrical and Computer Engineering Building, and research innovation projects for geothermal energy systems at the Illinois Energy Farm, the Bardeen Quad, and the Ven Te Chow Hydrosystems Laboratory are in progress. In FY20 a building-scale geothermal project was installed at the Campus Instructional Facility, saving 2,839 MMBTU per year.

In addition to the chilled water thermal energy storage tank described earlier, researchers are investigating thermal energy storage, such as advanced battery technologies using geothermal technology.

As clean energy technologies expand and become more viable, we can proactively equip campus buildings to accommodate them. One way to do this is by converting older buildings from steam heating to hot-water, low-temperature systems. Over 170 campus buildings still utilize steam for heating purposes inside the building.

Since 2010, all new campus buildings have been designed and constructed for hot-water heating systems, which require lower temperatures than steam. Similarly, as existing buildings have undergone refurbishment, steam heating systems have been replaced with hot-water systems. Hot-water systems are not only lower-cost to maintain, but are also easier to control, resulting in increased comfort for building occupants. Moving forward, we will continue to require the use of hot-water heating systems for all new construction.

Other key initiatives include converting inefficient HVAC systems to types that are compliant with current energy codes and updating the controls to reflect modern technology. These HVAC and control upgrades should be implemented in tandem with conversion to hot-water systems wherever possible in order to amplify efficiency and drive a better return on those investments. Together, these conversions can move campus buildings toward 100% hot-water heat, position us to use all potential clean energy technologies currently in existence, and contribute significantly to the university's goal of carbon neutrality by FY50.

> *"Energy conservation [efforts] in the last 10 years have been wondrously successful — if left on their own, then the conservation goals could be easily met. Without the square footage burden and Petascale burden, it's been really successful. But when we add the new square footage and Petascale, the total campus load is up, not down."*
>
> *— Bill Rose*

60 https://bit.ly/3jXZCAr

61 https://www.anl.gov/es/reference/renewable-natural-gas-database

Conclusion

Due to sheer volume and versatility of distribution, energy-based emissions occupy a major portion of the university's efforts toward carbon neutrality. In fact, energy generation and distribution is the leading contributor to campus GHG emissions.[62] Therefore, curtailing our energy consumption is essential to achieving carbon neutrality by FY50.

Improving the energy efficiency of our 650[63] university-owned buildings requires a cooperative effort. Beyond the ongoing energy efficiency work at F&S, we must facilitate a culture of sustainability throughout campus, with particular regard to departmental units and facility coordinators. While encouraging individual energy users to make consistent lifestyle changes is valuable, interacting directly with parties responsible for building-level energy management and further financial investment will substantially increase our impact. Additionally, as we work to balance ongoing safety measures with lasting sustainability practices, collaborating with high-level campus decision-makers is more critical than ever.

In the coming years, we intend to leverage a combination of strategic conservation measures, innovative renewable energy investments, and thorough campus outreach to reduce our carbon footprint as it pertains to energy use. With a concerted all-hands-on-deck effort, we can achieve significant progress.

62 https://icap.sustainability.illinois.edu/themes/energy

63 https://bit.ly/3jV4rKx

Geothermal loop and fiber optic cable installation on the Bardeen Quad, December 2018.

Credit: Tim Stark, professor of civil and environmental engineering, University of Illinois Urbana-Champaign.