

An aerial photograph of the NC State University campus. The image shows several large, multi-story brick buildings with flat roofs. A prominent feature is a tall, cylindrical brick chimney in the center. To the right, there is a large industrial-style building with several large circular cooling towers on its roof. The campus is surrounded by green trees and paved walkways. In the top left corner, there is a black rectangular box containing the text "NC STATE UNIVERSITY" in white, bold, sans-serif font.

**NC STATE  
UNIVERSITY**

# **ENERGY AND WATER ANNUAL REPORT**

**FISCAL YEAR 2022**

Energy and water are among NC State's most necessary and costly expenses. For more than a decade, the university's campus-wide energy management strategies have enabled significant conservation of fiscal and environmental resources. This report provides an update on campus progress toward utility reductions, highlights specific projects and outlines strategies for the next fiscal year that will contribute to further reductions.

## KEY PERFORMANCE INDICATORS

NC State tracks year-over-year change as well as change vs. baseline years. Overall performance vs. baseline shows a 35% decrease in Energy Use Intensity (EUI) and a 51% reduction in total water use per square foot on campus.

In FY 2022, students, faculty and staff were back on campus with energy intensive Covid-19 mitigation strategies in use. These strategies included increased outside air, longer HVAC operating hours and higher levels of air filtration. The result was a higher EUI as compared to the Covid-19 years of FY 2020 and FY 2021, but still showing a reduction in EUI from FY 2019, the most recent year in which the campus was fully occupied. The table below highlights these percentage changes.

| FISCAL YEAR                                    | FY02*     | FY03      | FY16       | FY17       | FY18       | FY19       | FY20       | FY21       | FY22       | % CHANGE<br>(1 Year<br>vs FY21) | % CHANGE<br>(vs Pre-Covid<br>FY19) | %CHANGE<br>from<br>Baseline |
|--|-----------|-----------|------------|------------|------------|------------|------------|------------|------------|---------------------------------|------------------------------------|-----------------------------|
| UTILITY COST,<br>\$/ GSF                       |           | \$1.98    | \$1.78     | \$1.80     | \$1.85     | \$1.84     | \$1.60     | \$1.51     | \$1.93     | 23%                             | 5%                                 | -3%                         |
| ENERGY COST,<br>\$/ GSF                        |           | \$1.87    | \$1.52     | \$1.53     | \$1.58     | \$1.56     | \$1.34     | \$1.30     | \$1.70     | 31%                             | 9%                                 | -9%                         |
| WATER COST,<br>\$/ GSF                         | \$0.12    | \$0.11    | \$0.26     | \$0.28     | \$0.27     | \$0.28     | \$0.26     | \$0.21     | \$0.24     | 14%                             | -14%                               | 102%                        |
| ENERGY<br>CONSUMPTION<br>(BTU / GSF)           |           | 171,810   | 115,692    | 116,763    | 119,144    | 113,859    | 108,737    | 108,079    | 111,602    | 3%                              | -2%                                | -35%                        |
| POTABLE<br>WATER<br>CONSUMPTION<br>(CCF / GSF) | 0.066     | 0.054     | 0.032      | 0.034      | 0.031      | 0.033      | 0.030      | 0.024      | 0.027      | 13%                             | -18%                               | -59%                        |
| TOTAL WATER<br>CONSUMPTION<br>(CCF / GSF)      | 0.066     | 0.054     | 0.034      | 0.037      | 0.035      | 0.037      | 0.035      | 0.029      | 0.033      | 12%                             | -12%                               | -51%                        |
| CAMPUS AREA<br>GROSS SQUARE<br>FEET (GSF)      | 9,796,638 | 9,910,619 | 15,119,248 | 14,978,780 | 14,972,547 | 14,963,604 | 14,999,125 | 15,133,063 | 15,316,354 | 1.2%                            | 2.4%                               | 55%                         |
| HEATING<br>DEGREE DAYS                         |           | 3,592     | 2,633      | 2,512      | 3,374      | 3,151      | 2,744      | 3,136      | 2,697      | -14%                            | -14.4%                             | -25%                        |
| COOLING<br>DEGREE DAYS                         |           | 1,656     | 1,761      | 1,783      | 2,149      | 2,034      | 1,942      | 1,820      | 2,013      | 10.6%                           | -1.9%                              | 22%                         |

\* Baseline year for water cost and consumption per gsf is 2001-2002 as defined in Executive Order Number 26. For all other KPIs, the baseline year is 2002-2003.

# HIGHLIGHTS

The following are highlights and accomplishments of energy efficiency strategies implemented during fiscal year 2022:



NC State successfully funded more than \$1,515,000 of campus energy projects that resulted in projected annual savings exceeding \$960,000. Multiple projects ranging from whole building lighting upgrades to building controls upgrades were completed through cost-sharing programs with campus partners.



The in-house Commissioning Team's work continues to improve the efficiency of NC State buildings through mechanical equipment calibrations, sequence adjustments and HVAC schedule implementations. Partnering with Building Maintenance and Operations technicians, the team achieved \$2.5 million in savings in FY 2022.



Through collaboration among business units within the Facilities Division, Energy Management compiled the FY 2022 Reinvestment Act claim for more than \$3 million in energy savings. The Reinvestment Act of 2010, also known as NC House Bill 1292, allows NC institutions to capture a portion of energy and water savings for reinvestment in further conservation projects.



NC State's Energy Performance Contracts span 3 utility plants and 14 buildings across campus. Upgrades range from Combined Heat and Power ("Cogeneration") to HVAC systems upgrades. Each project has a guaranteed annual energy savings; when combined, these projects help NC State avoid at least \$10.5 million in utility costs per year.



Funding has been identified for the second phase of the Exterior Lighting LED Conversion project that converts existing pole-mounted lights to LED. This project increases energy efficiency and also enhances nighttime safety. The first phase converted nearly 1,200 existing pole-mounted lights to LED, while also installing over 150 new pole-mounted lights. With the first phase completed, NC State's pole-mounted exterior lighting is over 50% LED, and the overall project aims to save over \$100,000 annually in electricity costs with the more efficient LED lights. The second phase will continue these efforts by targeting over 300 lights on South Campus along with over 1,100 lights on Centennial Campus.



Campus Operations & Maintenance takes advantage of the university's multi-day winter holiday closure by incorporating a Holiday Energy Savings Initiative (HESI). Through this initiative, building temperature setpoints are lowered, unnecessary lights and equipment are turned off and doors and windows are closed throughout campus in an effort to reduce utility consumption. During the FY 2022 HESI, \$416,000 in energy costs were avoided, and since inception in 2005, the HESI program has accounted for over \$5,200,000 in energy cost avoidance.

# COMMITMENT

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NC State University has committed to the following energy management goals:

**GOAL 1:** By 2025, reduce total campus energy use intensity (EUI) by 40% from the FY 2003 baseline.

**GOAL 2:** Expand the amount of renewable energy used to meet NC State's needs.

**GOAL 3:** Reduce campus water consumption by 65% from the FY 2002 baseline.

**GOAL 4:** Contribute to NC State's total greenhouse gas (GHG) emissions reduction by 25% from the FY 2008 baseline.

**GOAL 5:** Collaborate to inform and empower the campus community for energy and water savings.

## ENERGY MANAGEMENT STRATEGIES (AND THE GOALS TO WHICH THEY APPLY)

**STRATEGY A:** Optimize building energy use through energy auditing, retro-commissioning, predictive maintenance, control upgrades, incentive programs and occupant education. *(Goals 1,3,4 and 5)*

**Tactic A1:** Use Building Energy Assessment Tool (BEAT) to compare building performance based on industry building energy standards.

**Continuous:** BEAT update cycle began in August 2021.

**Tactic A2:** Require building envelope commissioning for new capital projects.

**Some Progress:** Design Guidelines for building envelope commissioning are under development. The Plant Sciences Building completed in 2022 was the first building that required envelope commissioning prior to building acceptance.

**Tactic A3:** Upgrade obsolete building controls as necessary.

**Some Progress:** Several buildings across campus were upgraded in FY 2022. Additional building control upgrades are planned for FY 2023.

**Tactic A4:** Promote the Ultra Low Temperature Freezer Rebate Program to replace inefficient freezers with energy efficient ones.

**Continuous:** In FY 2022, 10 freezers were replaced with high efficiency models.

**STRATEGY B:** Reduce energy use in NC State's five central utility plants by 5% from the 2015 baseline. *(Goals 1,3 and 4)*

**Tactic B1:** Install variable frequency drives (VFDs) on utility plant pumps.

**Some Progress:** VFDs on 2 chilled water and 1 condenser water pump at Cates and Yarbrough Utility Plants are a work in progress for FY 2023.

**Tactic B2:** Recommission the utility plants and optimize the system curves.

**Some Progress:** Efforts are ongoing to improve the controls and sequence of operation of the chilled water and condenser system water loops at the Veterinary school utility plant. Similar efforts could be used across all other utility plants on campus.

**Tactic B3:** Conduct steam trap surveys to identify failed traps for replacement.

**Continuous:** Annual steam trap survey and repair in utility plants and distribution tunnels.

**Tactic B4:** Conduct boiler tune-ups.

**Continuous:** Tune-ups are performed annually on all utility plant boilers to ensure optimal operation.

**STRATEGY C:** Explore and develop best practices for smart infrastructure and energy generation use in campus buildings. (Goals 1,2, 3,4 and 5)

**Tactic C1:** Construction of solar and battery energy storage systems for multiple campuses.

**In Progress:** Efforts are ongoing to install the solar PV system at Fitts-Wollard Hall. Also, the Battery Energy Storage System (BESS) at Partners I is under review by the State Construction Office (SCO) and awaiting authority to bid. The completion of both projects is expected for FY 2023.

**Tactic C2:** Incorporate chilled water Thermal Energy Storage (TES) at the Centennial Campus Utility Plant.

**Complete:** TES tank is operational.

**STRATEGY D:** Reduce potable water consumption across all campuses. (Goals 3 and 4)

**Tactic D1:** Employ reuse (reclaimed or non-potable) water for toilets, irrigation, etc. on Centennial Campus.

**Some Progress:** Fitts-Woolard Hall and the new Plant Sciences Building use reuse water for irrigation and domestic sanitation.

**Complete:** Centennial Campus Utility Plant uses reuse water for cooling tower make-up.

**Tactic D2:** Reduce potable water use in campus buildings and utility plants. Assess novel and proven technologies to guide efforts.

**Complete:** Jordan Hall cooling tower replacement to reduce the amount of water loss due to tower degradation.

**In Progress:** Project is underway to reroute water previously sent to the drain for use as boiler makeup water.

**On Hold:** Partnership with NC State Stewards to equip student volunteers with tools to test bathroom faucet flow rates and replace with low-flow faucet aerators as needed in academic buildings. The Covid-19 pandemic put this on hold and is expected to resume in FY 2023.

## PROJECTS COMPLETED DURING FISCAL YEAR 2022

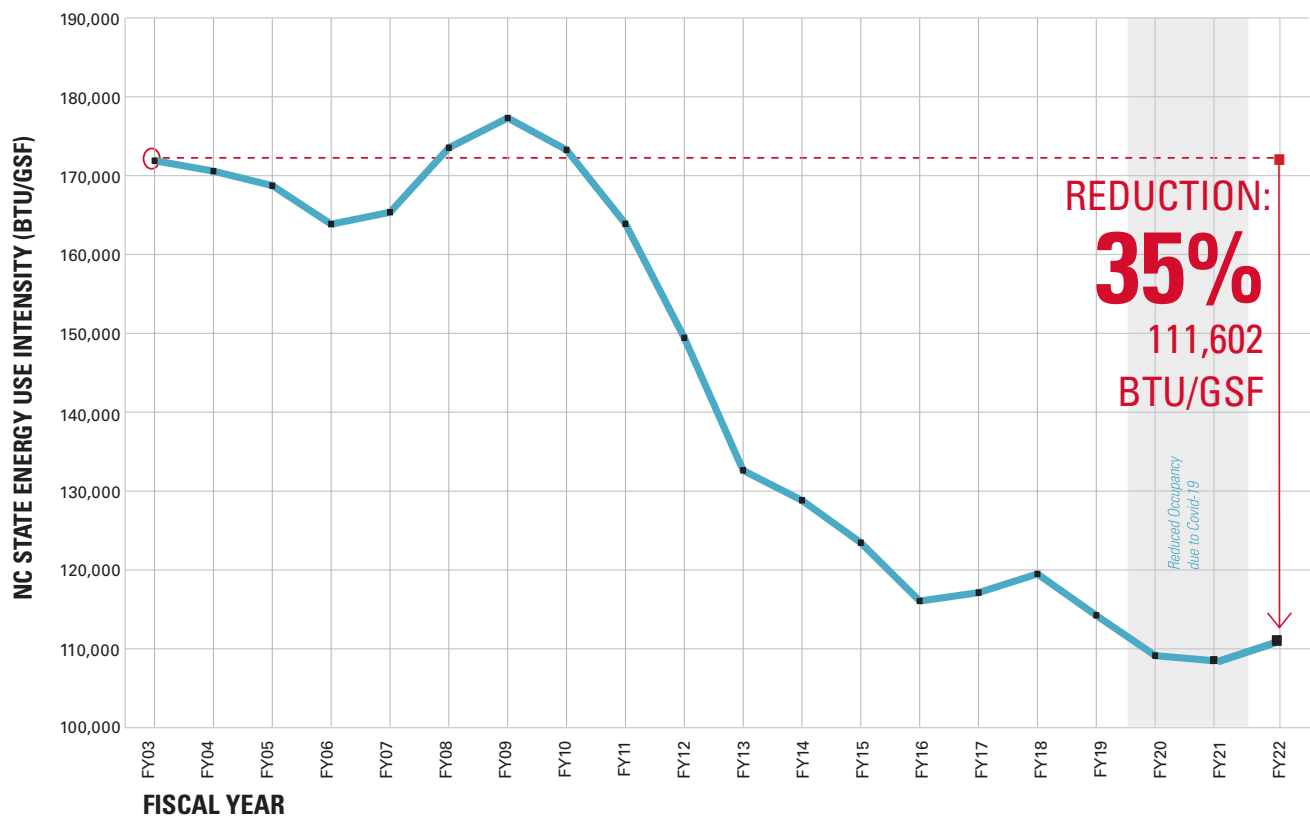
| PROJECT  | COST      | ESTIMATED ANNUAL COST AVOIDED | SIMPLE PAYBACK (YEARS) |
|--|-----------|-------------------------------|------------------------|
| Holiday Energy Savings Initiative                                      | \$20,000  | \$416,000                     | 0                      |
| ULT Freezer Rebate Program   | \$37,500  | \$5,000                       | 7                      |
| Schaub Hall, College of Veterinary Medicine, Holmes Hall Recommissions | \$209,000 | \$228,000                     | 1                      |
| Headhouse Unit III LED   | \$325,00  | \$130,000                     | 3                      |
| Cates Lighting Replacement/Upgrades                                    | \$12,000  | \$5,400                       | 2                      |
| CBC Chilled Water Loop Temperature Optimization                        | \$256,000 | \$53,700                      | 5                      |
| Carmichael Recreation Center Controls Upgrades                         | \$139,600 | \$32,000                      | 4                      |
| Controls Upgrades for Various Buildings                                | \$279,000 | \$64,000                      | 4                      |
| Reynolds Coliseum LED Lamp Retrofit                                    | \$23,500  | \$11,500                      | 2                      |
| DH Hill Library LED Light Fixture Upgrade                              | \$1,200   | \$350                         | 3.5                    |
| Engineering Building I - Replace Pneumatic Controls with DDC           | \$100,000 | TBD after RCx                 | TBD after RCx          |
| MRC - Replace Pneumatic Controls with DDC                              | \$100,000 | TBD after RCx                 | TBD after RCx          |
| Cates Plant LED Upgrade Lighting on Roof                               | \$3,000   | \$750                         | 4                      |
| Annual Steam Trap Survey   | \$2,500   | \$10,000                      | 0                      |
| Yarbrough Steam Plant LED Upgrade Lighting for Cooling Towers          | \$7,000   | \$2,800                       | 2.5                    |

# PERFORMANCE

## ENERGY

Campus energy consumption peaked in fiscal year 2009 and has trended downward since. Reduced occupancy on campus during the pandemic produced a greater energy reduction in 2020 and 2021 than would have otherwise been achieved. Energy-intensive Covid-19 mitigation strategies such as higher air filtration, increased outdoor air levels and longer hours of HVAC operation to allow flushing of air before and after building occupancy for safety increased energy usage in 2021-2022. Compared to the FY 2003 baseline, total energy consumption per gross square foot (GSF) has decreased by 35% in FY 2022.

### NC STATE ENERGY USE INTENSITY (BTU/GSF)



*\*Combined Heat and Power Adjustment Methodology: NC State purchases electricity, natural gas, fuel oil, and potable and reuse water from third parties. Electricity is also generated by using an 11 megawatt (MW) CHP system on main campus and a 6.5 MW CHP system on Centennial campus. As a result of CHP, fuel use for on-site power generation increases, fuel use for boilers decreases, and grid electricity purchases (or source energy) decreases.*

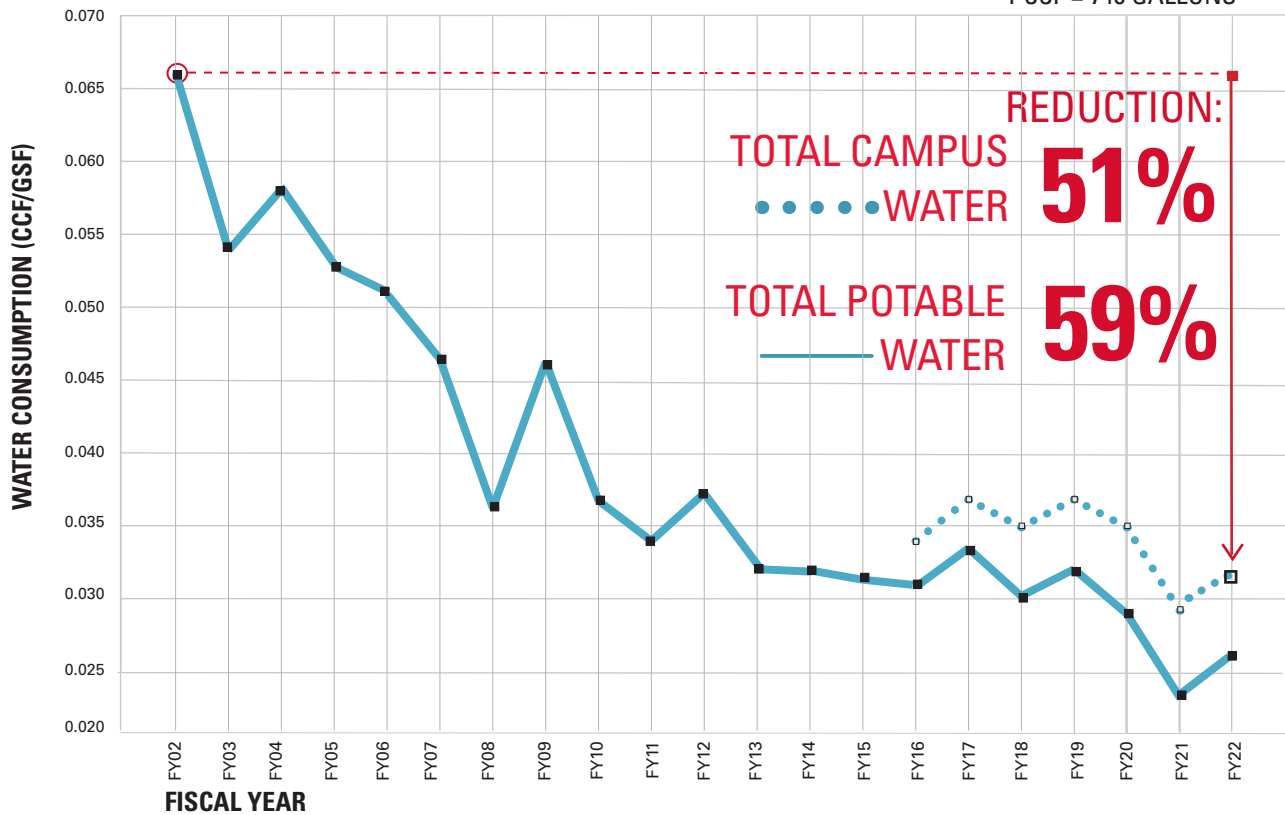
*The methodology for reporting the benefits garnered through the operation of CHP follows the U.S Department of Energy measurement protocol outlined by the Federal Energy Management Program in the Reporting Guidance for Federal Agency Annual Report on Energy Management issued October 2018. The purpose of the adjustment is to not penalize organizations under the site energy based performance metric for implementing cost-effective projects where source energy decreases but site-delivered energy increases.*

## WATER

In fiscal year 2016, NC State began utilizing non-potable reuse water supplied by the City of Raleigh on Centennial Campus. Reuse water is wastewater treated to a high standard and reused instead of being discharged into a waterway. Reuse water provides a more cost-effective and drought resistant supply of water for cooling towers, irrigation and toilet flushing. For total water consumption (potable and reuse), FY 2022 marked a level 51% below the FY 2002 baseline with potable water consumption decreased by 59%.

**NC STATE TOTAL WATER CONSUMPTION: POTABLE AND REUSE (CCF/GSF)**

1 CCF = 748 GALLONS



### WHY DOES REUSE WATER INCREASE TOTAL WATER CONSUMPTION?

Reuse water is less expensive and more sustainable than potable water because it has received less processing, and thus has less embedded energy in its production. Because of this, the Centennial Campus Utility Plant cooling towers primarily use reuse water. Cooling towers work by evaporating heat from water to the outdoor air. As water evaporates, impurities

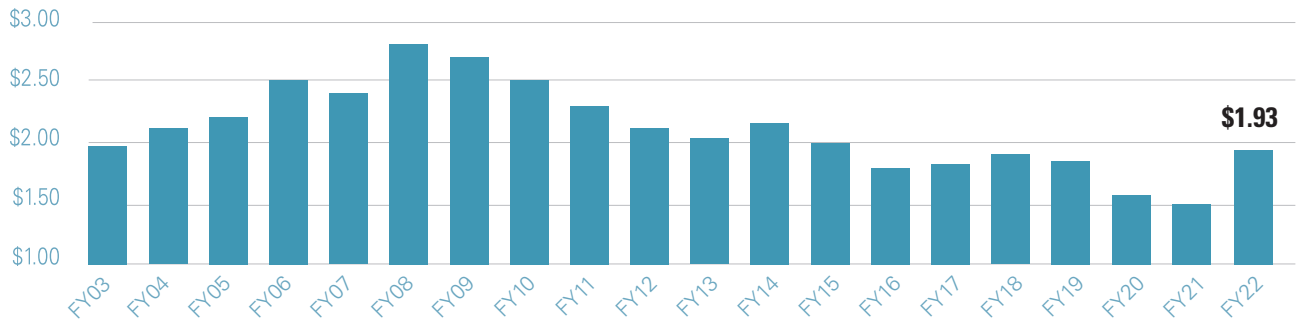
in the water build up and require that the water be replaced periodically. Because reuse water has more impurities than potable water, it must be replaced more frequently. However, the benefits of reuse water—primarily the decreased costs and embedded energy savings—outweigh the additional water use.

# PROGRESS

Total Utility Cost per GSF sharply increased in FY 2022 due to price increases from all utility providers along with significantly higher fuel oil usage. More fuel oil was required because natural gas was curtailed for a total of 10 days in January 2022, which equates to approximately a third of the month. Although fuel oil was only 3% of the energy purchased, fuel oil accounted for 6% of the total utility cost.

For FY 2022, the Total Utility Cost per GSF is \$1.93/GSF, which is 2.5% lower than the 2002-2003 baseline. This is despite energy costs which have increased by 39% and water prices that have increased by 347% since FY 2003. Energy and water efficiency gains, coupled with low natural gas prices and Energy Management’s strategic purchasing of natural gas, have all contributed to the gradual reduction in Total Utility Cost per GSF. Higher utility prices and severe weather patterns could reverse this trend.

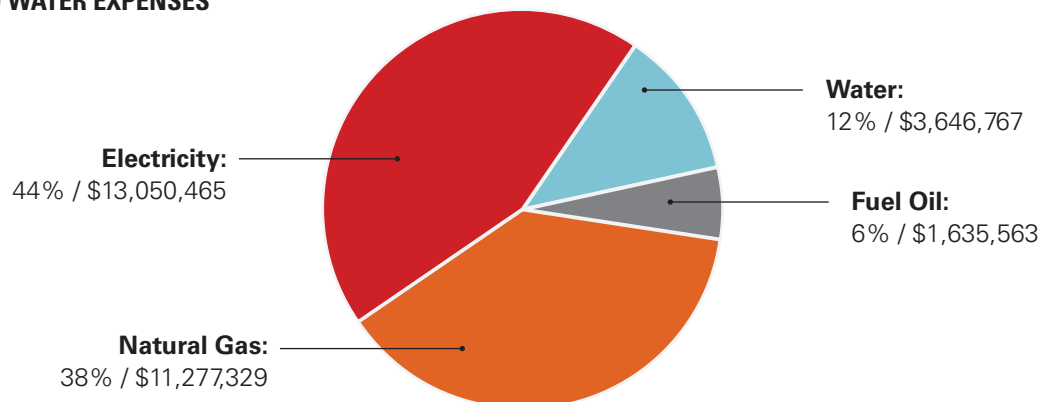
## UTILITY COST PER GROSS SQUARE FOOT (GSF)



Each year, NC State typically purchases approximately \$30 million in utilities. During FY 2022, electricity accounted for 44% of the utility purchase total. Electricity is the utility most influenced by the campus community and, as such, has the greatest potential for reduction through conservation actions by individuals such as turning off lights, unplugging electronics not in use, closing windows and doors, shutting fume hood sashes in labs and turning off computers not in use.

As for other utilities, natural gas was curtailed for a third of January which forced the campus to purchase fuel oil. This accounted for 6% of the utility expense after zero fuel oil was purchased for the prior fiscal year.

## ENERGY AND WATER EXPENSES

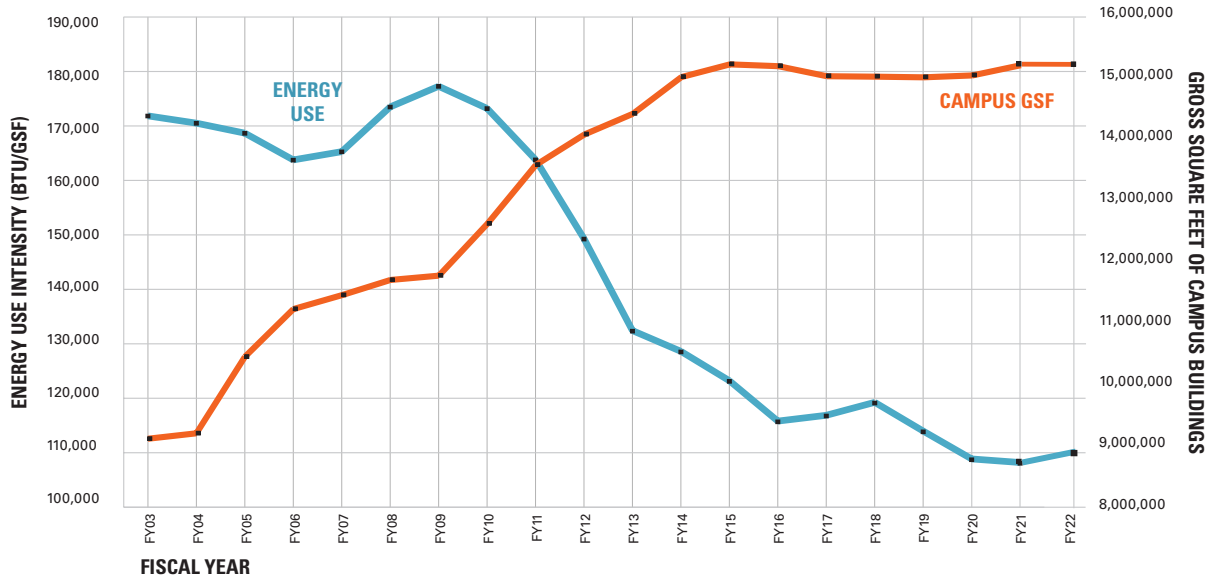




**CAMPUS GROWTH VS. PERFORMANCE**

The university’s growth versus Energy Use Intensity over time is illustrated below. As indicated by this figure, although campus GSF has increased by 55% since the 2002/2003 baseline, EUI has decreased by 35%. The university continues to make significant progress in reducing energy use through energy efficiency strategies and efforts by the campus community (see page 3).

**NC STATE ENERGY USE INTENSITY AND CAMPUS GROWTH**



**FISCAL YEAR 2023 PROJECTS PLANNED**

| PROJECT   | COST        | ESTIMATED ANNUAL COST AVOIDED | SIMPLE PAYBACK (YEARS) |
|---|-------------|-------------------------------|------------------------|
| ULT Freezer Rebate Program  | \$37,500    | \$5,000                       | 7                      |
| Recommissioning of Carmichael Recreation Center & Gym, Joyner Visitor Center, EBI & MRC           | \$760,000   | \$300,000                     | 3                      |
| Fitts-Woolard Hall Solar Photovoltaic Array   | \$500,000   | \$40,275                      | 12.5                   |
| Battery Storage - Centennial Campus Infrastructure  | \$465,000   | \$53,210                      | 8.7                    |
| BTEC LED Tube Lighting Upgrades   | \$12,000    | \$5,000                       | 2                      |
| LED Conversions (Interior Lighting) - CVM Main, Williams Hall, Kamphoefner, Toxicology, Polk Hall | \$1,918,000 | \$399,500                     | 5                      |
| LED Conversions (Exterior Lighting) - South & Centennial Campuses                                 | \$750,000   | \$277,700                     | 3                      |
| Controls Upgrades - MRC, PSC, MDF   | \$340,000   | TBD after RCx                 | TBD after RCx          |
| Chiller Pump VFD Upgrades - Yarbrough & Cates   | \$409,500   | \$40,000                      | 10                     |
| Lab Building Exhaust VAV Conversion - FOX   | \$16,600    | \$10,000                      | 2                      |
| EB II Aeroseal Duct Work  | \$84,000    | \$68,000                      | 1                      |
| Biltmore Fume Hood Removal  | \$12,000    | \$5,000                       | 2                      |
| Annual Steam Trap Survey  | \$2,500     | \$10,000                      | 0                      |
| Cates Plant LED Upgrade Lighting in Plant Room  | \$11,500    | \$4,600                       | 2.5                    |
| Toxicology Hallway LED Upgrades   | \$30,000    | \$6,000                       | 5                      |
| Toxicology Hallway LED Upgrades   | \$50,000    | \$8,000                       | 6                      |
| Headhouse 1 LED Upgrade   | \$275,000   | \$68,000                      | 4                      |

# ENERGY PERFORMANCE CONTRACTING

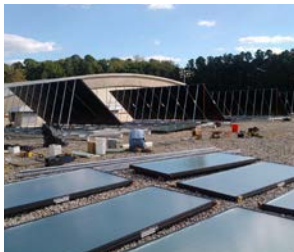
NC State utilizes energy performance contracting (EPC) to upgrade facilities and systems, avoid operational expenses and reduce emissions. The university currently has four EPCs.



## **COGENERATION EPC ON CENTRAL AND NORTH CAMPUS (2012)**

*17-year contract, \$56.1 million investment*

In 2012, this project replaced aging boilers in both the Cates and Yarbrough Central Utility Plants with new high efficiency boilers and a cogeneration system. The cogeneration system, or “combined heat and power,” utilizes natural gas to produce 11 MW of electricity while the waste heat from the process produces steam. Utility savings are realized due to a reduction in the total cost of electricity and steam production through increased efficiency. In FY22, the Cates Cogeneration plant produced approximately 31% of the university’s electricity and helped to reduce the university’s greenhouse gas emissions by using cleaner fuel sources and by reducing NC State’s reliance on the regional electricity grid. The most recent annual savings for this performance contract was over \$8.7 million.



## **13 BUILDING EPC (2012)**

*19-year contract, \$19.7 million investment*

The 13 Building EPC encompasses the following buildings: Cox Hall, Poe Hall, Tompkins Hall, Caldwell Hall, Winston Hall, Wilson College of Textiles, McKimmon Center, Monteith Research Center, Research I, Dabney Hall, Carmichael Gym, Constructed Facilities Lab and MRC Parking Garage. The EPC included renovations and operational changes with the HVAC systems and fume hood controls, lighting upgrades, water reduction strategies and a solar hot water system in Carmichael Gym. The most recent annual savings exceeded \$2 million.



## **PHYTOTRON BUILDING EPC (2014)**

*15-year contract, \$6.2 million investment*

Constructed in 1968, the Phytotron Building performs plant, animal and insect research by simulating environments from desert heat and drought to Alpine cold and jungle humidity. The Phytotron EPC addressed HVAC and lighting upgrades, a connection to the central chilled water loop and research equipment improvements. Phytotron’s most recent annual savings were over \$680,000.



## **CENTENNIAL CAMPUS COGENERATION EPC (2019)**

*18-year contract, \$17 million investment*

Centennial Cogeneration EPC removed a boiler in the Centennial Central Utility Plant and installed a high efficiency cogeneration system. The cogeneration system includes a combustion turbine generator (CTG) which generates 5.5 MW of electricity, and a steam turbine generator (STG) which is capable of generating an additional 1 MW of electricity from the excess steam. Utility savings are realized due to a reduction in the total cost of electricity and steam production through increased efficiency. In FY 2022, CCUP’s Cogeneration provided over 17% of the university’s electricity while helping to reduce greenhouse gas emissions. The most recent annual savings exceeded \$1.7 million.

# RENEWABLE ENERGY

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Expanding NC State's renewable energy portfolio is a significant component of our efforts toward advancing our climate action commitments. As such, multiple strong efforts are being planned across campus to boost renewable generation and energy storage deployment.

Recently, a 157kW<sub>DC</sub> Fitts-Woolard Hall PV went through the bid process and was awarded. The project is now in the construction phase for FY 2023. Similarly, the Centennial Campus battery storage project is in review. When complete, the storage is expected to shave up to 500kW of the Centennial Campus peak demand.

The potential for other new solar installations are in the advanced planning phase. Design and feasibility analysis are being conducted to install 1.04MW of solar canopies over the new parking lot at Varsity Drive. This would allow the university to better understand structural requirements, PV panel and electrical equipment selection, electrical single line design, performance modeling, and provide for a phased construction approach supported by a construction estimate for each phase.

Also, an engineering senior design team is participating in the design of solar arrays at the Sullivan Shops. This is accompanied by a study to deploy battery energy storage and electric vehicle charging stations at the same sites. Such efforts when completed will provide the feasibility to significantly lessen our campus peaks and to generate more energy savings.

Another partnership effort is being exercised by the Wilson College of Textiles and the Facilities Division to invest in solar energy generation on Centennial Campus. This is still in the conceptual phase of planning. The energy management goal is to move the effort forward to an advanced planning phase with a formal design.

The Strategic Energy and Water Annual Report  
is produced by NC State Energy Management

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