

NC STATE
UNIVERSITY



STATE
COLLEGE

ENERGY AND WATER ANNUAL REPORT

FISCAL YEAR 2023

EXECUTIVE SUMMARY

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.

The **2023 Energy and Water Annual Report** provides an overview on campus progress in reducing utility usage from July 1, 2022 through June 30, 2023. It also highlights key projects and outlines strategies for the next fiscal year aimed at further energy and water usage reductions.

The university has set ambitious goals for energy and water reduction, resulting in significant accomplishments in FY 2023. For example, there was a 35% reduction in energy consumption and 55% total water usage reduction compared to the 2002/2003 baselines. These achievements are being made despite a 54% increase in gross square footage over the same timeframe.

This demonstrated commitment to conservation creates significant energy savings. A major contributor to these savings are two campus cogeneration plants, which generate nearly 50% of the university's annual electricity needs. Additionally, leveraging reuse water provided by the City of Raleigh has been instrumental in water conservation efforts.

NC State Energy Management is dedicated to cost-effectively managing the energy and water resources consumed by the university to minimize usage while maintaining comfort levels for building occupants. With an overall utility spend of over \$28 million for FY 2023, fluctuations in petroleum and electricity prices are monitored and tracked closely. Projects to reduce utility consumption and to improve efficiency are consistently developed and installed, including four energy performance contracts that continue to deliver a return on investment.

Moving forward, the university remains dedicated to exploring new energy-saving opportunities and minimizing utility costs. Energy Management is committed to guiding these endeavors and prioritizing energy conservation and efficiency initiatives.

GOALS

NC State University has committed to the following goals related to energy, water, and climate neutrality. These goals provide a direction and target for all energy and water conservation efforts. They also provide a benchmark against which progress can be measured.

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.

KEY PERFORMANCE INDICATORS

NC State tracks year-over-year change as well as change vs. baseline years of 2002/2003. Overall performance vs. baseline shows a 35% decrease in Energy Use Intensity (EUI) and a 55% reduction in total water use per gross square foot on campus. Potable water consumption has decreased by 61%. These reductions have occurred despite a 54% increase in campus gross square footage since FY 2003. This means although a significant number of new buildings have been added, total campus energy consumption has still decreased by over one-third.

The data shown below is measured against NC State's 40% energy and 65% water reduction goals. In addition, the number of heating or cooling degree days reflects the amount of energy needed to heat or cool a building to a comfortable temperature, given how cold or hot it is outside. With 30% fewer heating degree days, the FY 2023 winter was milder than the baseline.

FISCAL YEAR	FY02*	FY03	FY21	FY22	FY23	% CHANGE (1 Year vs FY22)	%CHANGE from Baseline
UTILITY COST, \$ / GSF		\$1.98	\$1.51	\$1.93	\$1.89	-2%	-5%
ENERGY COST, \$ / GSF		\$1.87	\$1.30	\$1.70	\$1.66	-2%	-11%
WATER COST, \$ / GSF	\$0.12	\$0.11	\$0.21	\$0.24	\$0.23	-4%	93%
ENERGY CONSUMPTION (BTU / GSF)		171,810	108,079	111,602	111,114	-0.4%	-35%
POTABLE WATER CONSUMPTION (CCF / GSF)	0.066	0.054	0.024	0.027	0.026	-4%	-61%
TOTAL WATER CONSUMPTION (CCF / GSF)	0.066	0.054	0.029	0.033	0.030	-8%	-55%
CAMPUS AREAGROSS SQUARE FEET (GSF)	9,796,638	9,910,619	15,133,063	15,316,354	15,293,378	-0.2%	54%
HEATING DEGREE DAYS		3,592	3,136	2,697	2,499	-7.3%	-30%
COOLING DEGREE DAYS		1,656	1,820	2,013	1,850	-8.1%	12%

* 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.

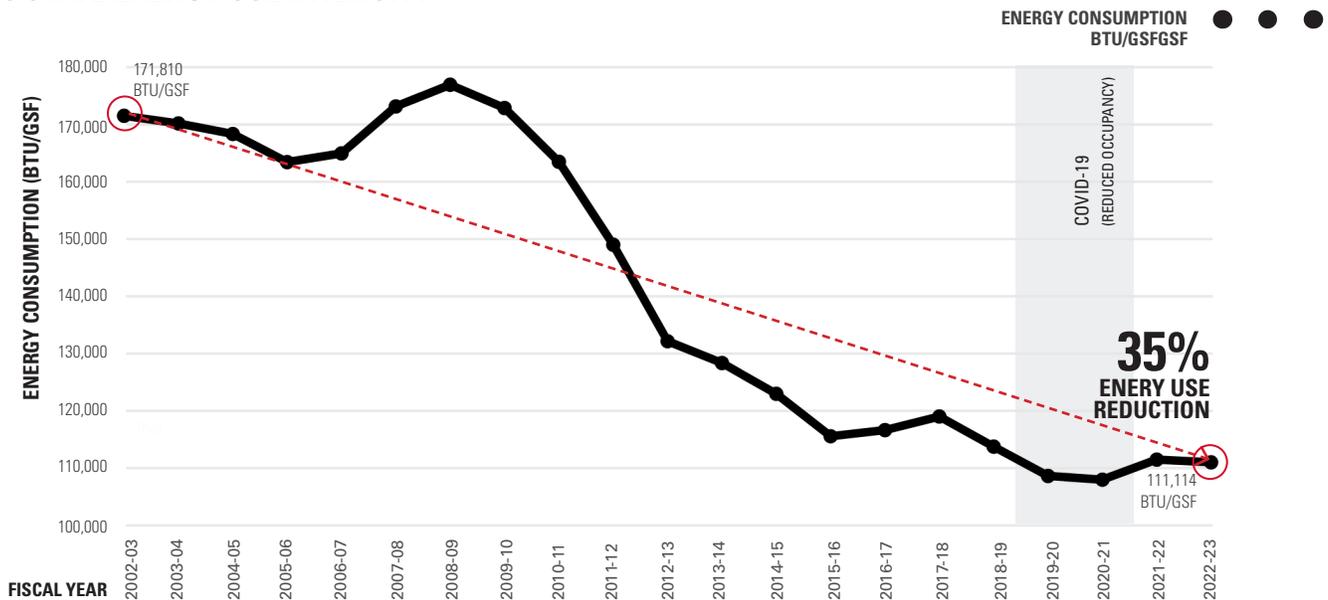
CAMPUS ENERGY USE

Campus energy consumption peaked in FY 2009 and has trended downward since, driven by a legislative mandate in 2007 for state-owned buildings to reduce energy usage. This directive prioritized energy management, leading to the implementation of various conservation measures, including improved lighting, HVAC systems and efficient scheduling.

During the pandemic, reduced campus occupancy resulted in a greater energy reduction in 2020 and 2021 than would have otherwise been achieved. However, energy-intensive mitigation strategies such as enhanced air filtration, increased outdoor air levels and extended HVAC operation hours increased energy usage in 2021 and 2022. Comparing to the FY 2003 baseline, total energy consumption per gross square foot (GSF) decreased by 35.3% in FY 2023.

As NC State works towards its 40% energy reduction goal, identifying new conservation measures becomes challenging, coupled with increased costs for advanced equipment and a 54% increase in campus GSF since the FY 2003 baseline. Despite these challenges, the university continues to make significant progress in reducing energy use through energy efficiency strategies such as operational improvements, facility upgrades, outreach and education.

NC STATE ENERGY USE INTENSITY



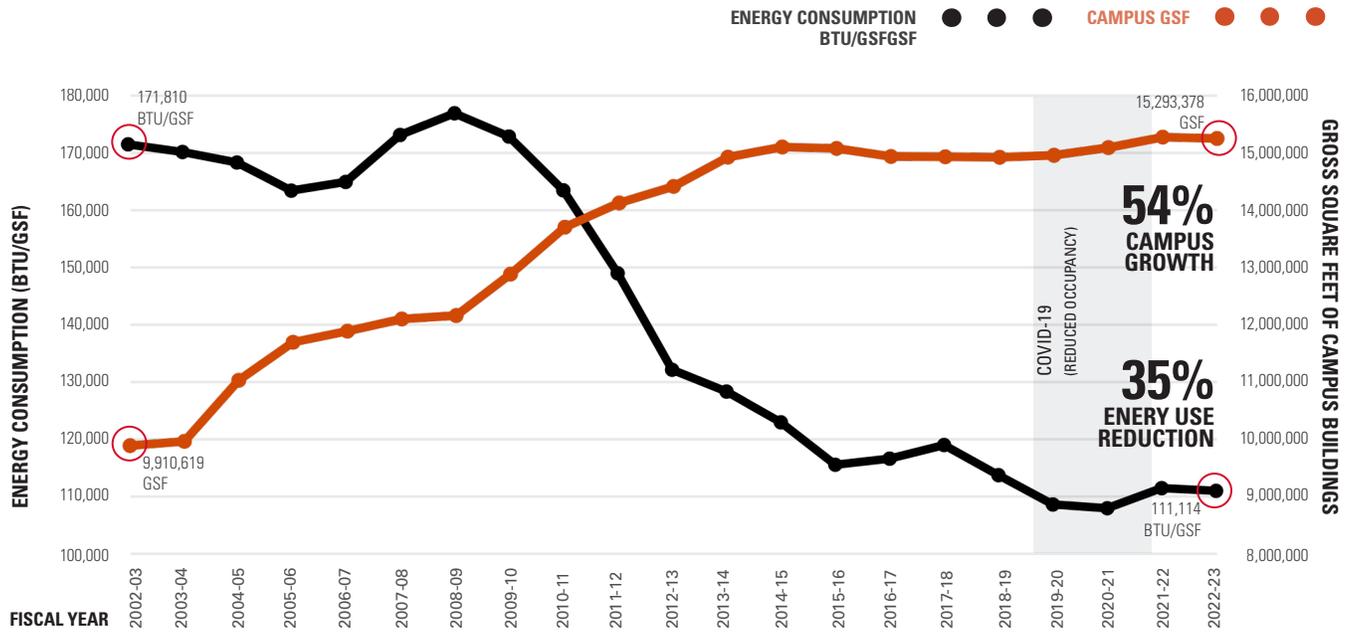
Combined Heat and Power (CHP) Adjustment Methodology

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 September 2023. 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.

The university's growth versus Energy Use Intensity (EUI) over time is illustrated in the following chart, which indicates that although campus GSF has increased by 54% since the 2002/2003 baseline, EUI has decreased by 35%.

NC STATE ENERGY USE INTENSITY AND CAMPUS GROWTH



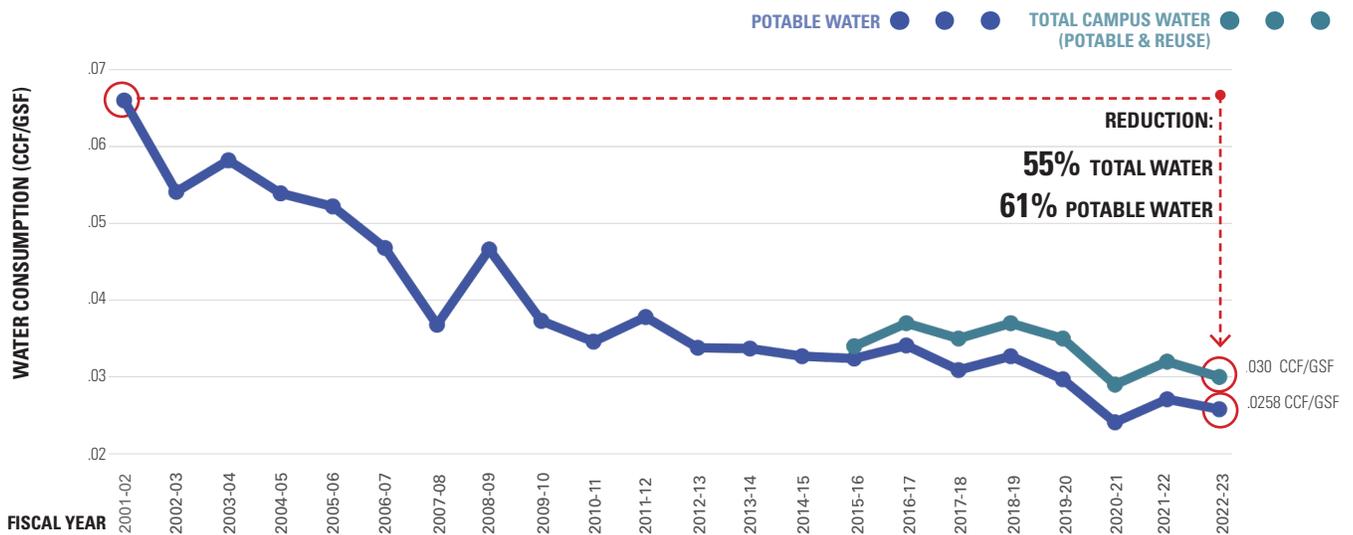
CAMPUS WATER USE

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 utility plant cooling towers, campus irrigation and toilet flushing in certain campus buildings.

The following graph illustrates the university's total campus water consumption (potable and reuse) and potable consumption since the baseline year of FY 2002. For total water consumption (potable and reuse), FY 2023 marked a level 55% below the FY 2002 baseline with potable water consumption decreased by 61%. Reuse water was not available for approximately four months because the City of Raleigh had to repair the campus reuse water line. This resulted in increased potable water usage during the outage.

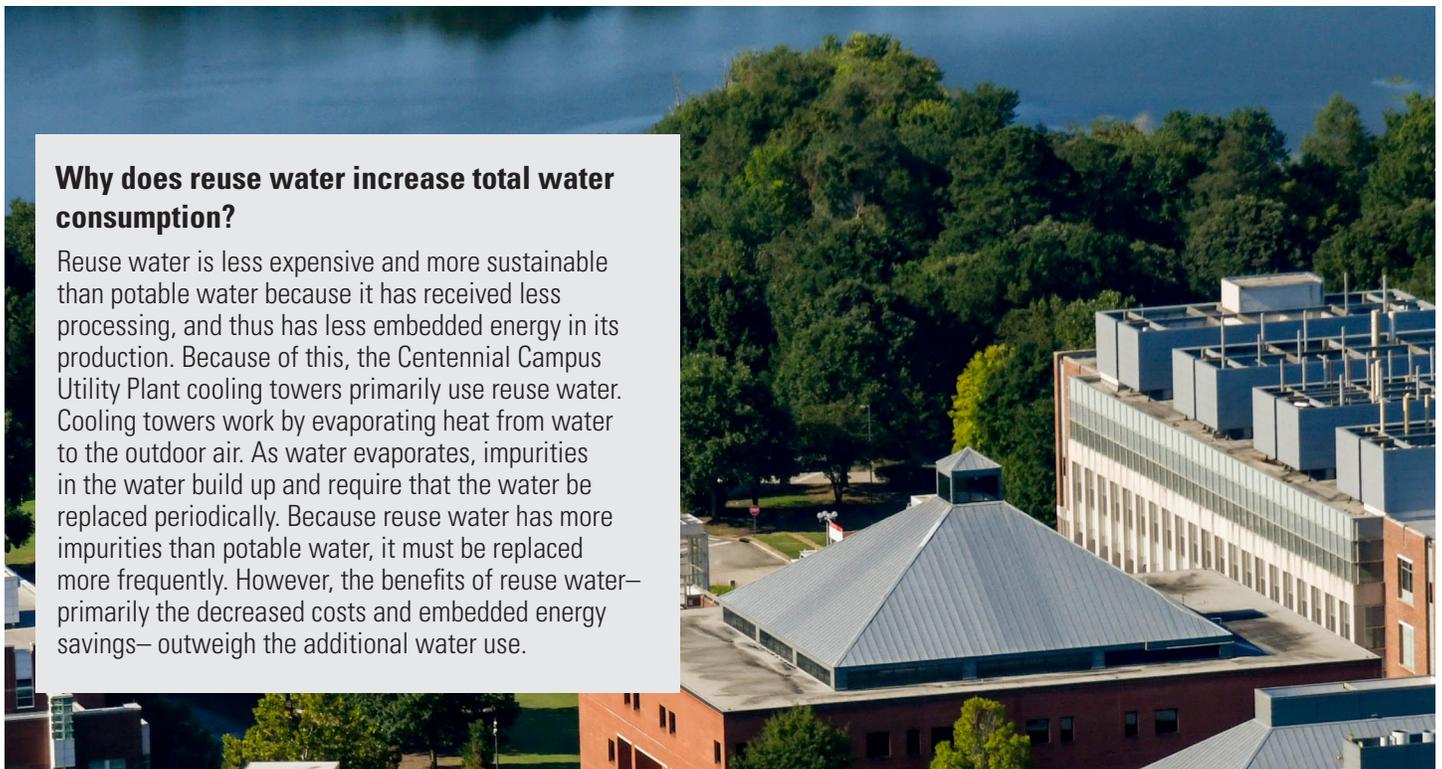
NC STATE TOTAL WATER CONSUMPTION: POTABLE AND REUSE (CCF/GSF)

1 CCF=748 US GALLONS



Why does reuse water increase total water consumption?

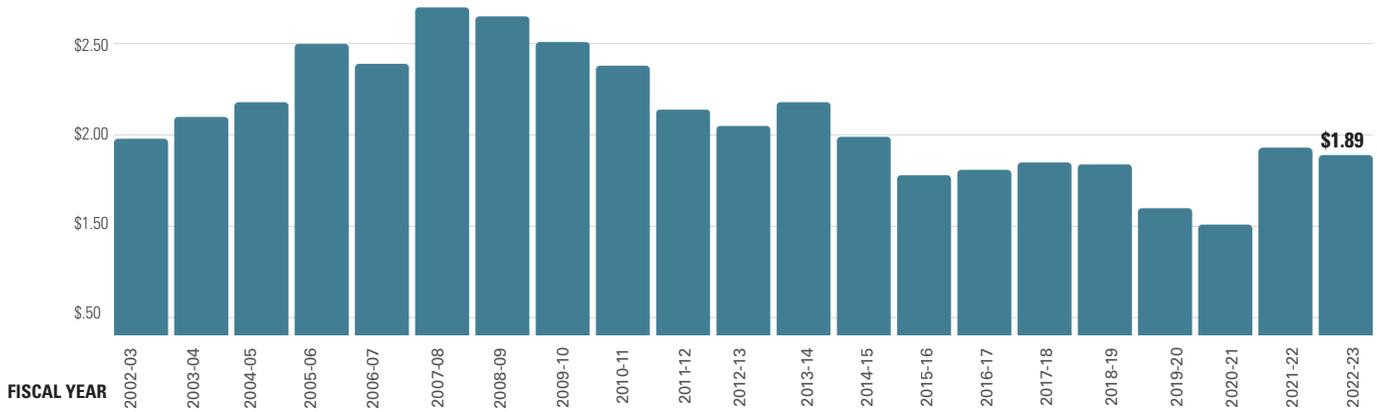
Reuse water is less expensive and more sustainable than potable water because it has received less processing, and thus has less embedded energy in its production. Because of this, the Centennial Campus Utility Plant cooling towers primarily use reuse water. Cooling towers work by evaporating heat from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



UTILITY COSTS

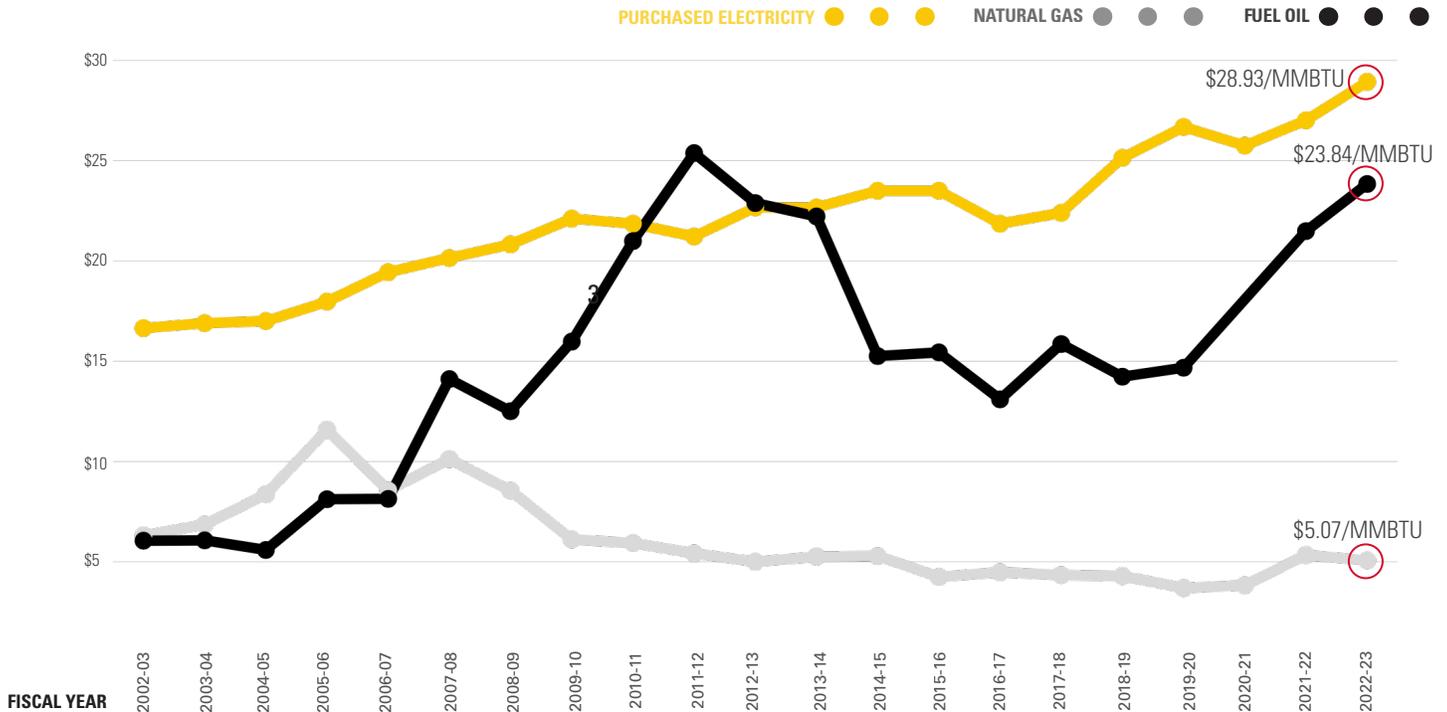
NC State spent over \$28 million on total utilities during FY 2023. The overall utility costs per gross square foot (GSF) experienced a slight decrease, from \$1.93 in FY 2022 to \$1.89 in FY 2023. The chart below illustrates the combined utility costs per GSF since the baseline years of 2002/2003, peaking in 2008/2009 alongside campus energy usage. Reduced campus occupancy during the pandemic resulted in a noticeable decrease in costs. The post-pandemic return to campus, coupled with increased gas prices, has contributed to higher combined costs.

UTILITY COSTS PER GROSS SQUARE FOOT (GSF)



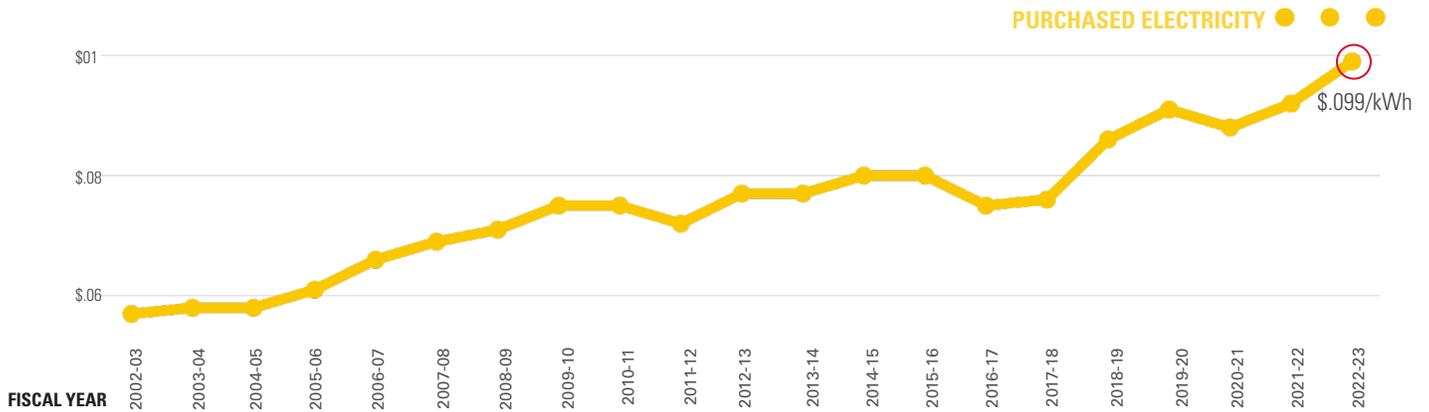
FY 2022 had very high gas prices, which persisted into the first half of FY 2023, but was offset by very low prices in the second half of the fiscal year. The following chart shows the average annual energy price for purchased electricity, natural gas, and fuel oil on a dollar per MMBTU basis in order to show the relative cost of each utility per unit of energy provided.

AVERAGE ENERGY PRICES (\$/MMBTU)

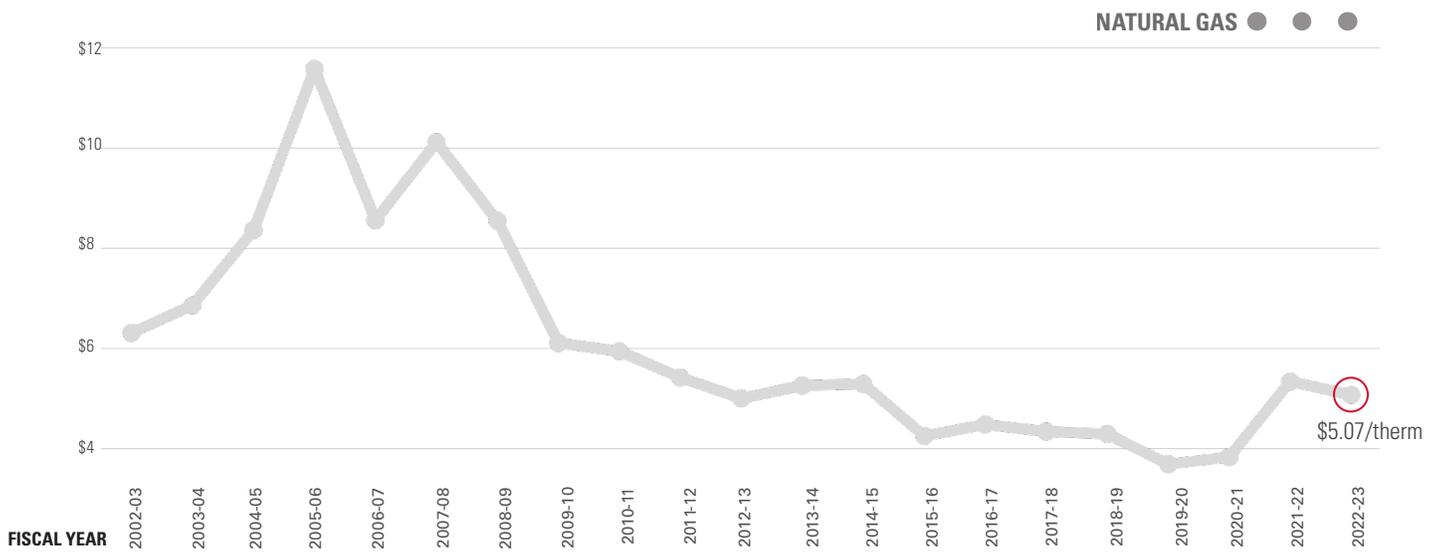


The charts below provide a breakdown of the cost of each utility per billable unit. This shows how the cost of each utility has changed over time. All except for natural gas have gotten more expensive over time.

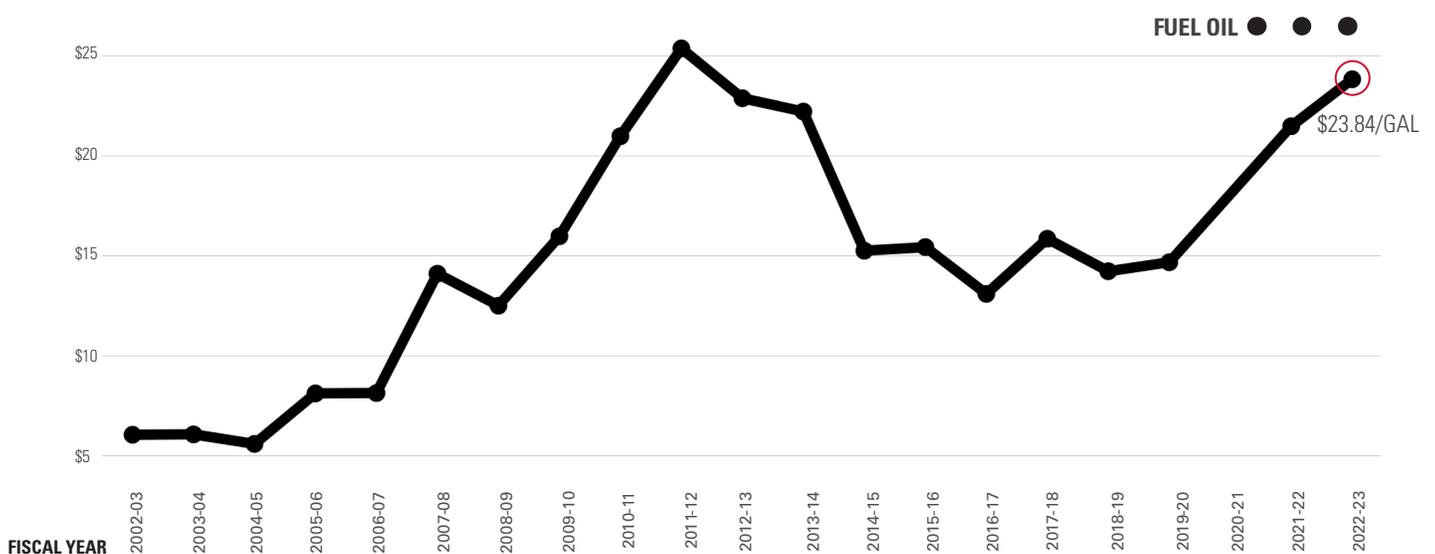
PURCHASED ELECTRICITY (\$/kWh)



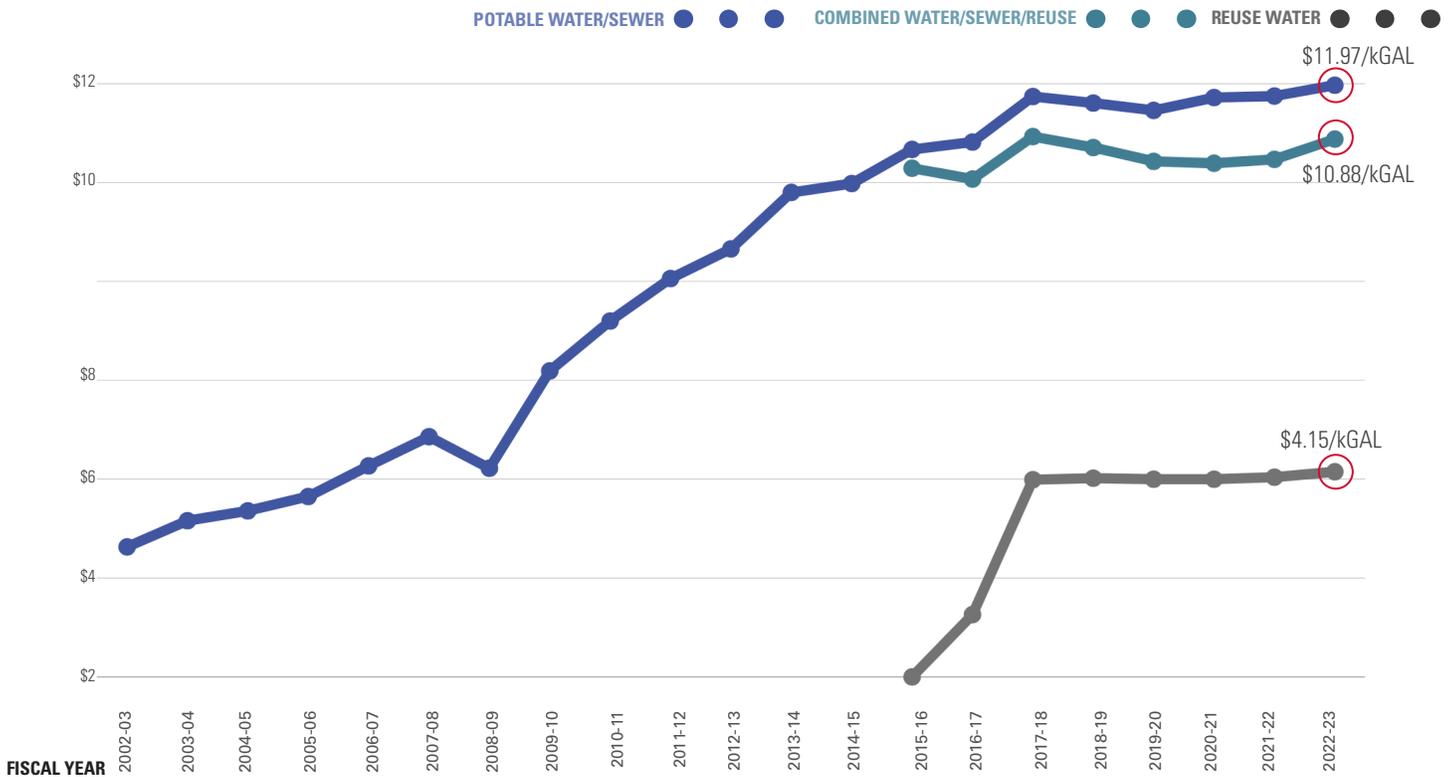
NATURAL GAS (\$/therm)



FUEL OIL (\$/GAL)

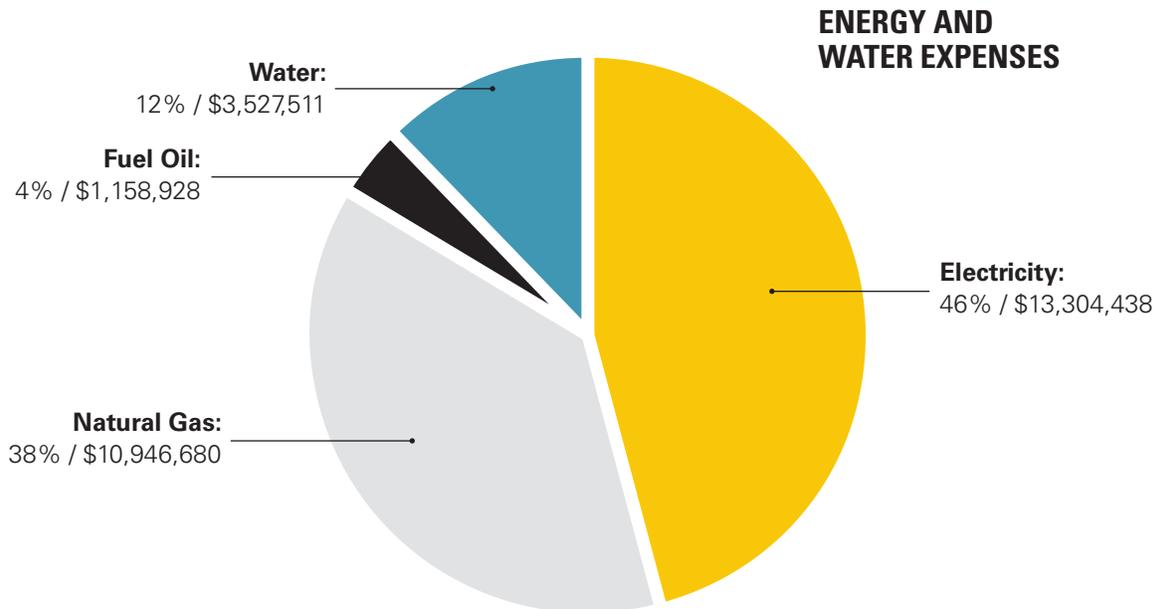


WATER PRICES (\$/kGAL)



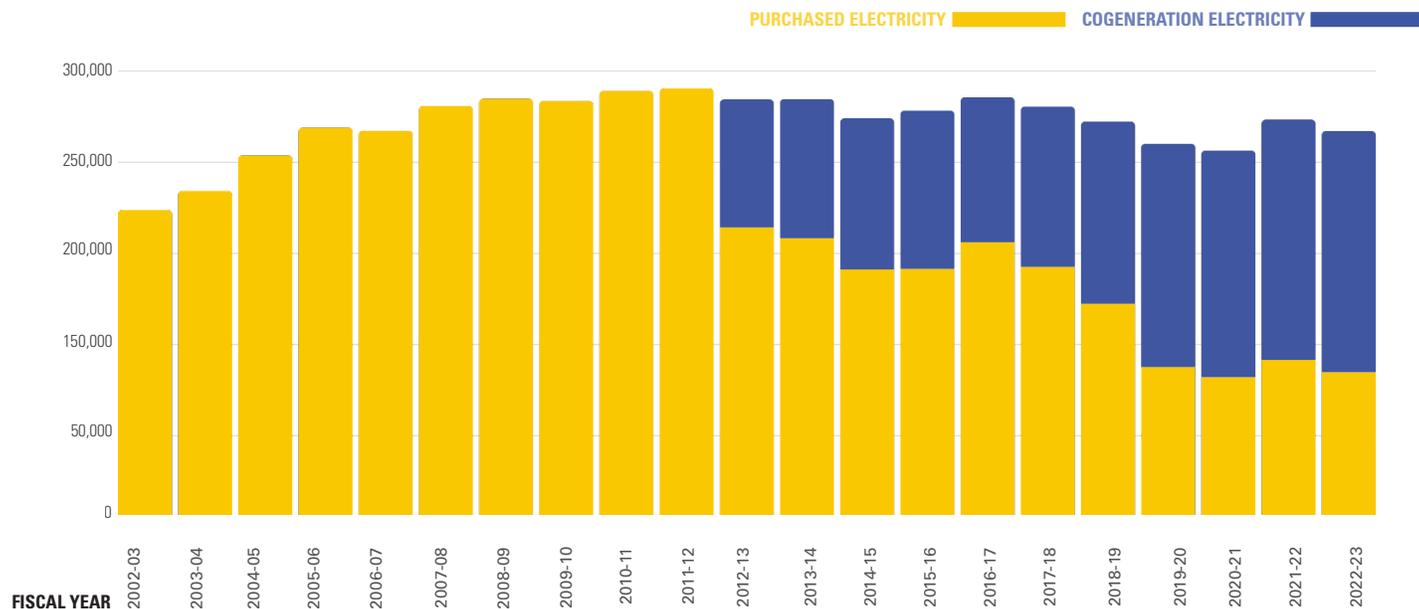
Electricity is the largest component of purchased utilities at a cost of \$13,304,438. Electricity is the utility most influenced by the campus community and, as such, has the greatest potential for reduction through conservation actions by individuals such as turning off lights, unplugging electronics not in use, closing windows and doors, shutting fume hood sashes in labs and turning off computers not in use.

Although fuel oil only comprises 4%, the cost is relatively high at \$1,158,928. The university tries to minimize the use of fuel oil throughout campus, but if natural gas is curtailed by the supplier, campus utility plants must utilize fuel oil to maintain operations. During FY 2023, natural gas was curtailed for a total of 10 days.



One significant impact to purchased electricity costs for the university has been the installation of combined heat and power cogeneration plants on both Central and Centennial campuses. These cogeneration plants produce a maximum rate of 16.5 MW electricity. This directly offsets electricity that has to be purchased. Installed in 2012, the first cogeneration installation contributed over 70,000 MWh of energy during the first year of operation. This cogeneration contribution is shown below in blue. With the addition of cogeneration on Centennial campus in 2019, purchased electricity was reduced by almost an additional 20%.

PURCHASED vs. CoGEN ELECTRICITY (MWh)



STRATEGIES

Energy Management uses multiple strategies to conserve energy across campus. The team diligently cultivates its expertise, continually keeping pace with the latest emerging technologies and trends in energy and water conservation. Staff actively participates and presents in conferences such as the State Energy Conference of North Carolina and the Appalachian Energy Summit. Energy Management also manages and promotes annual energy saving initiatives such as:

- › Holiday Energy Savings Initiative
- › Summer Energy Savings Initiative
- › Ultralow Temperature Freezer Rebates
- › Fume Hood Decommissioning
- › Natural Gas Strategic Procurement
- › NC State Utility Reduction Program
- › Energy Audits
- › Annual Steam Trap Survey

These initiatives are widely publicized to help increase energy conservation awareness and engagement with faculty, staff and students. In addition, various online articles are regularly submitted to campus weekly and monthly publications in order to advertise special events, project successes and upcoming conservation opportunities. Energy Management also maintains the website, energymanagement.ncsu.edu, for anyone who wishes to learn more about campus energy use, existing conservation programs and NC State's progress towards reduction goals.

Energy Management’s chief effort towards the 40% energy reduction goal is through energy conservation projects, including:

FISCAL YEAR 2023 ENERGY PROJECTS	STATUS	BUDGET	FUNDING SOURCE	ESTIMATED ANNUAL SAVINGS	SIMPLE PAYBACK (YEARS)
ULT Freezer Rebate Program	Ongoing	\$ 50,000	DSM/EE	\$ 10,000	5
Annual Steam Trap Survey	Ongoing	\$ 2,500	DSM/EE	\$ 10,000	0
Fume Hood Decommissioning Program	Ongoing	\$ 15,000	DSM/EE	\$ 5,000	3
Energy Risk Management Consultant	Ongoing	\$ 34,800	DSM/EE	NA	NA
Purchase Trial Energy Management System	Completed	\$ 41,636	DSM/EE	NA	NA
Recommissioning of Carmichael Recreation Center & Gym, Joyner Visitor Center, & Schaub	Completed	\$ 170,000	DSM/EE	\$ 315,000	0.54
Language and Computer Labs - Network Engine Upgrades	Completed	\$ 2,929	DSM/EE	TBD after RCx	TBD after RCx
Phytotron - Network Engine Upgrades	Completed	\$ 3,394	DSM/EE	TBD after RCx	TBD after RCx
Main Distribution Frame - Network Engine Upgrades	Completed	\$ 3,394	DSM/EE	TBD after RCx	TBD after RCx
Public Safety Building - Actuator Upgrade	Completed	\$ 39,200	DSM/EE	TBD after RCx	TBD after RCx
Turlington & Alexander - Replace Mechanical Fan Coil Thermostat Controllers	In Progress	\$ 160,000	DSM/EE	\$ 31,500	5.1
EB II Aeroseal Duct Work	Completed	\$ 86,687	DSM/EE	\$ 68,000	1.3
Biltmore Fume Hood Removal	Completed	\$ 12,000	DSM/EE	\$ 5,000	2.4
BTEC LED Tube Lighting Upgrades	Completed	\$ 7,733	DSM/EE	\$ 5,000	1.5
Cates Plant LED Upgrade Lighting in Plant Room	Completed	\$ 11,316	DSM/EE	\$ 4,600	2.5
Toxicology Hallways & Common Spaces LED Upgrades	Completed	\$ 27,407	DSM/EE	\$ 6,000	4.6
Carmichael Gym (Gymnastics Facilities) Lighting Upgrade	Completed	\$ 44,325	DSM/EE	\$ 6,000	7.4
Headhouse 1 LED Upgrade	Completed	\$ 252,292	DSM/EE	\$ 68,000	3.7
Chiller Pump VFD Upgrades - Yarbrough & Cates	Completed	\$ 251,607	DSM/EE	\$ 40,000	6.3
Recommissioning of EBI	In Progress	\$ 150,000	DSM/EE	TBD	TBD
Page Hall Mechanical & Electrical Upgrade	In Progress	\$ 468,948	HB1292	NA	NA
Fitts-Woolard Hall Solar Photovoltaic Array	In Progress	\$ 509,625	HB1292	\$ 23,800	21.4
Battery Storage - Centennial Campus Infrastructure	In Progress	\$ 500,000	HB1292	\$ 85,400	5.6
LED Conversion - CVM Main	In Progress	\$ 740,000	HB1292	\$ 220,000	3.4
LED Conversion - Williams Hall	In Progress	\$ 360,000	HB1292	\$ 96,000	3.8
LED Conversions (Exterior Lighting) - South & Centennial Campuses	In Progress	\$ 889,880	HB1292	\$ 277,700	3.2
Controls Upgrades - MRC & PSC	In Progress	\$ 338,731	HB1292	TBD after RCx	TBD after RCx
Schaub Phase II Ventilation Study & Implementation	In Progress	\$ 43,500	F&A	\$ 108,900	0.4
Mary Anne Fox Phase II Ventilation Study & Implementation	In Progress	\$ 40,000	F&A	\$ 42,420	1
Schaub Steam Trap Replacements	In Progress	\$ 10,000	F&A	\$ 40,000	0.3
Schaub Energy Improvements Phase I - Resolve RCx Findings	In Progress	\$ 36,500	F&A	\$ 30,000	1.2
Meter Upgrades - Multiple Buildings Implementation	In Progress	\$ 57,500	F&A	NA	NA

FISCAL YEAR 2024 ENERGY PROJECTS	STATUS	BUDGET	FUNDING SOURCE	ESTIMATED ANNUAL SAVINGS	SIMPLE PAYBACK (YEARS)
ULT Freezer Rebate Program	Ongoing	\$ 50,000	DSM/EE	\$ 10,000	5
Annual Steam Trap Survey	Ongoing	\$ 2,500	DSM/EE	\$ 10,000	0.3
Fume Hood Decommissioning Program	Ongoing	\$ 15,000	DSM/EE	\$ 5,000	3
Energy Risk Management Consultant	Ongoing	\$ 40,200	DSM/EE	NA	NA
Nelson & MRC - Purchase materials to support Lighting Project	Proposed	\$ 758,156	HB1292	TBD	TBD
Outreach/Communication Strategy Development with University Communications	In Progress	\$ 25,000	F&A	NA	NA
Professional Study and testing of potential eDNA replacement	In Progress	\$ 50,000	F&A	NA	NA
Advanced Planning/Design Sullivan Shops Solar PV	In Progress	\$ 40,000	F&A	NA	NA
Advanced Planning/ Phased Design Varsity Lot Solar PV	In Progress	\$ 50,000	F&A	NA	NA
MRC supply fans and Return fan AHU VFDs Installation	In Planning	\$100,000	DSM/EE	\$97,500	1
Poe Hall Duct Sealing	In Planning	\$ 150,352	DSM/EE	\$ 13,962	10.8
Caldwell Hall Duct Sealing	In Planning	\$12,682	DSM/EE	\$2,320	5.5
Toxicology Lab Energy Reduction from Exhausts	In Planning	\$ 361,250	DSM/EE, F&A	\$ 100,000	3.6
MRC - Building Retrocommissioning	In Planning	\$165,000	DSM/EE	TBD after RCx	TBD after RCx



ENERGY PERFORMANCE CONTRACTS

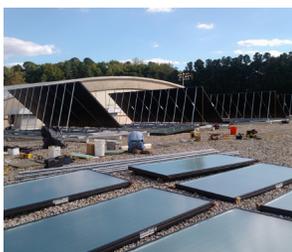
NC State utilizes energy performance contracting (EPC) to upgrade facilities and systems, avoid operational expenses and reduce emissions. The university currently has four EPCs.



COGENERATION ON CENTRAL AND NORTH CAMPUS (2012)

17-year contract, \$56.1 million investment

In 2012, this project replaced aging boilers in the Yarbrough Central Utility Plant with new high efficiency boilers and installed two combined heat and power cogeneration systems at the Cates Utility Plant. The cogeneration system 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. These systems also allow NC State to produce almost 50% of the electricity needed annually. The most recent annual savings for this performance contract was over \$8.9 million.



13 BUILDING EPC (2012)

19-year contract, \$19.7 million investment

This project installed renovations and operational improvements with HVAC system and fume hood controls, lighting upgrades, and water conservation strategies in a total of 13 buildings across the campus. These buildings were: 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 most recent annual savings for this performance contract 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 for this performance contract exceeded \$800,000.



CENTENNIAL CAMPUS COGENERATION EPC (2019)

18-year contract, \$17 million investment

This project 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. The most recent annual savings for this project exceeded \$900,000.

RENEWABLE ENERGY

A renewable energy portfolio is a strategic tactic to advance NC State's climate action goals. The university is actively exploring, planning and capitalizing on incentives for integrating renewable energy technologies. These efforts will boost renewable generation and deploy energy storage. The following projects represent the initial phase of these technologies entering campus:

Fitts-Woolard Hall Solar Array:

A 154kW/DC ballasted rooftop solar array on Fitts-Woolard Hall is underway. This installation is the largest solar project on campus to date. This system will directly connect to the building, reducing reliance on fossil fuels for building operations. Upon completion in FY 2024, Energy Management will monitor real-time data on system performance.

Centennial Battery Storage:

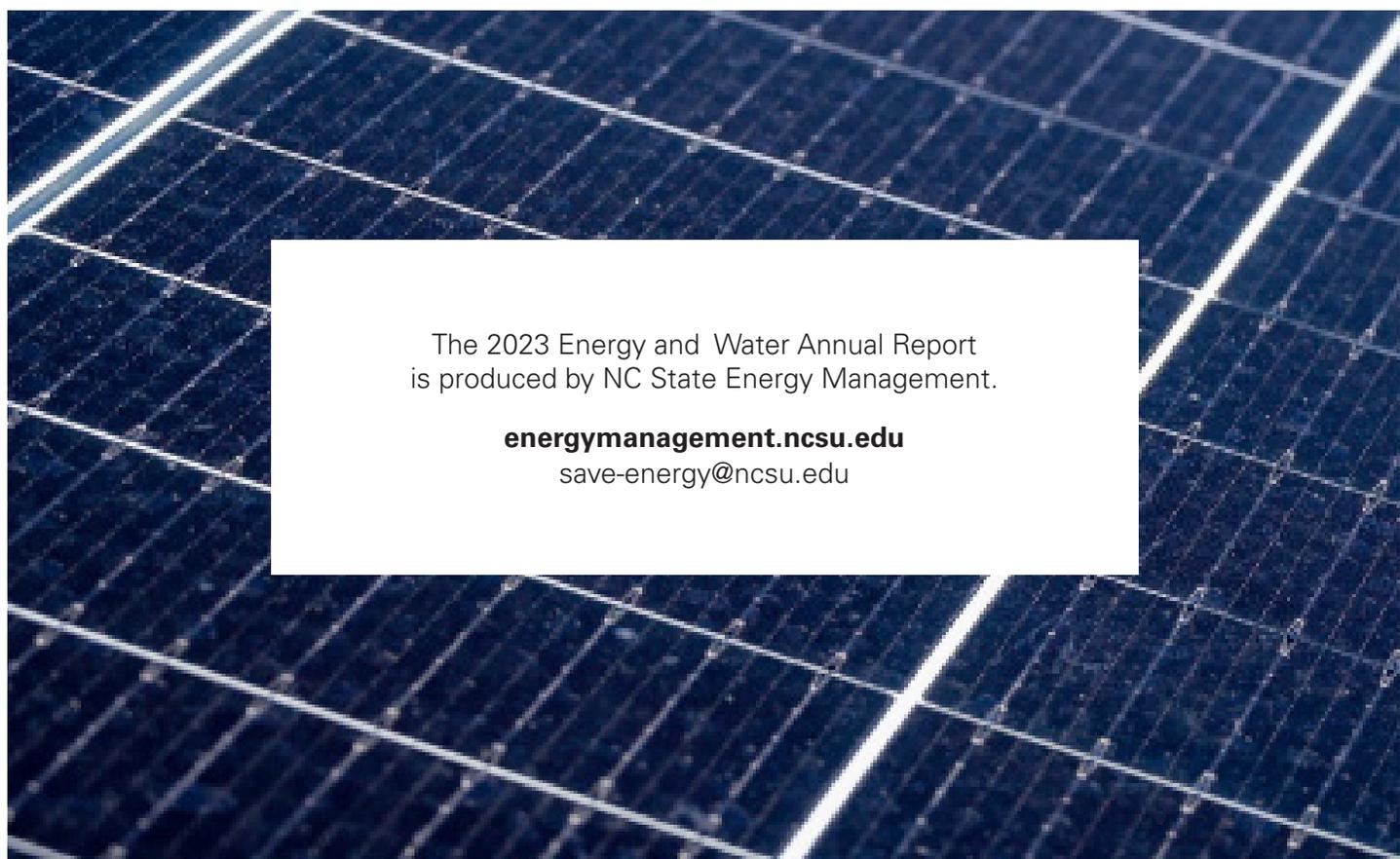
Outside of Partners I, a 250kW battery is being installed to support the solar PV system on the roof of Fitts-Woolard Hall. Energy will be stored in the batteries and discharged during peak times in order to reduce the cost of purchased electricity. This project will be completed in fiscal year 2024.

Future Projects:

Energy Management is in the planning phase to place solar arrays at both the Varsity Parking Lot and Sullivan Shops Complex. These systems are expected to produce 1.06 MW/AC and 600 kW/AC, respectively.

Sustainability:

The University Sustainability Office supports Energy Management's goals by providing data tracking, outreach and communication efforts. This includes maintaining NC State's Greenhouse Gas Inventory, which shows a 23.2% reduction in greenhouse gas emissions on campus from FY 2008 to FY 2022. The Sustainability Office also maintains an online and interactive campus sustainability map featuring high performance buildings and solar infrastructure.



The 2023 Energy and Water Annual Report
is produced by NC State Energy Management.

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