Updated Strategic Energy Plan

With Usage from FY 2020-21

Submitted September 1st, 2021

Office of Sustainability & Energy Management

Facilities Management

Prepared by: David King, C.E.M.

Special thanks to our controls technician Duane Strain, as well as our HVAC, Plumbing, and Electric Shops who are a daily reminder that "No one of us is as smart as all of us"

Western Carolina UNIVERSITY

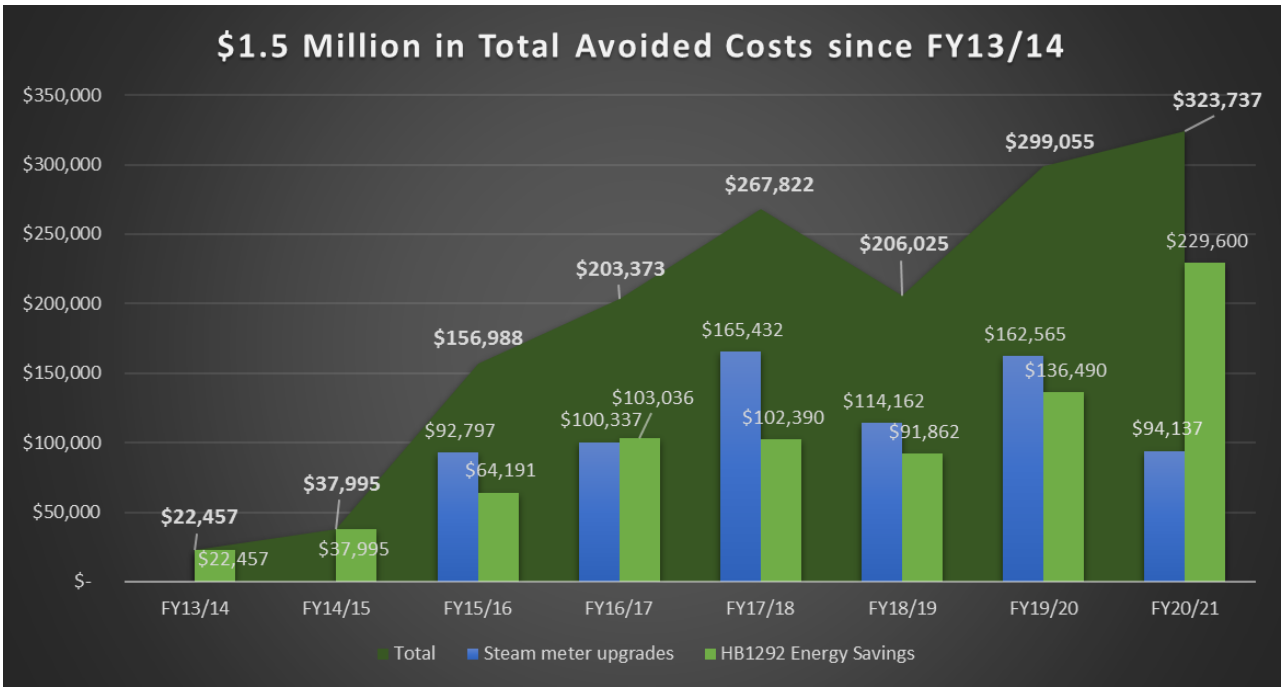
Executive Summary

Approach

Commercial buildings waste on average 30% of their energy (*DOE, 2019*). WCU's approach to energy management therefore focuses on demand-side management by implementing no-cost to low-cost proven conservation and energy efficiency measures first. This is accomplished via the building automation system (BAS) which is software that operates two-thirds of the campus heating, ventilation, and air conditioning (HVAC) which can represent 40-50% of a building's total energy usage (*EIA, 2017*).

"*You can't manage what you don't measure*." While this is an old business adage, it is central to energy management at WCU. Investments in metering have allowed WCU to benchmark energy usage for 95% of the 40 largest buildings on campus compared to 12% in FY12/13. This has brought to light that five buildings account for almost 25% of all utility costs on campus (see pg. 6)

Summary of Fiscal Year 20/21:



- Total avoided costs of over $1.5 million since 2013 ($800,000 in energy savings, $700,000 in recovered steam plant operational costs)

- Submitted $229,000 in House Bill 1292 energy savings carry forward (13 projects compared to 9 for the previous year). For perspective, the electric savings alone (2.7 million kWh) would require over $4,000,000 in solar to generate.

- Recovered $94,137 in steam plant operations (over $700,000 in recovered steam plant operational costs since 2013)

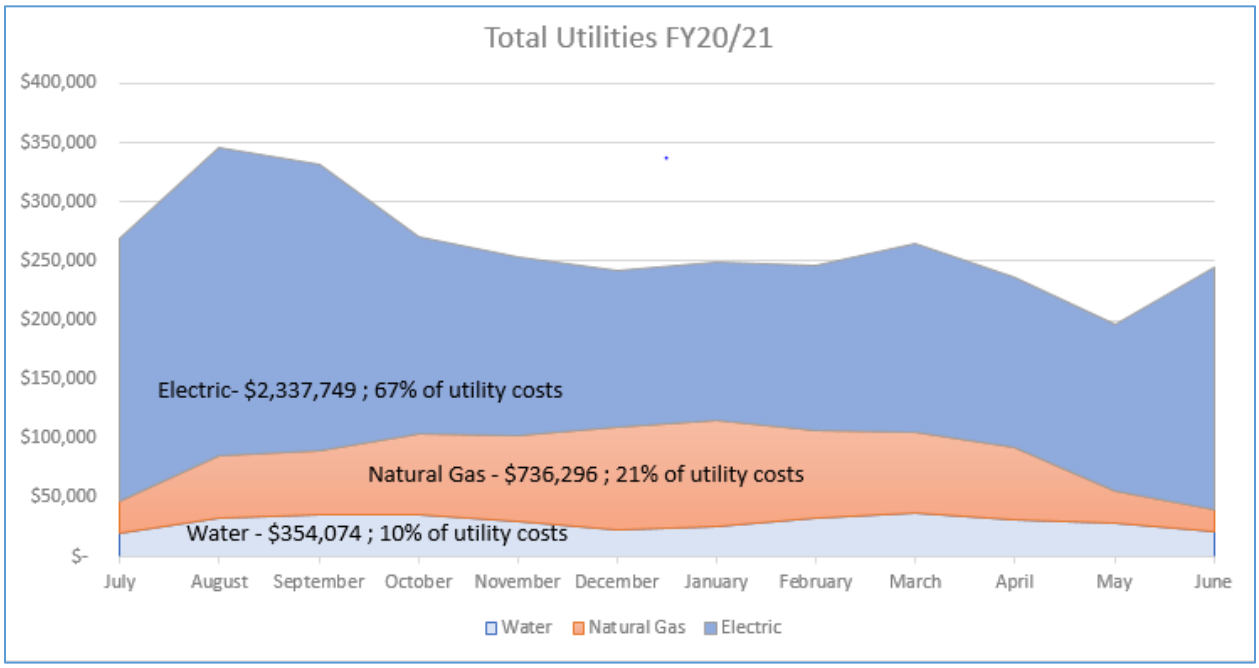
- Replaced 1990's era controls at the Hunter chiller plant and have reduced usage by almost 50% in the first 6 months for an avoided cost of over $30,000. As of July, the largest chiller is now only used for redundancy. On the older system, it was not uncommon to see all three chillers running.

- Completed controls upgrade of the Ramsey Arena air handlers from pneumatic to direct digital control (DDC) and replaced original hot water and chilled water valves on all 7 units.

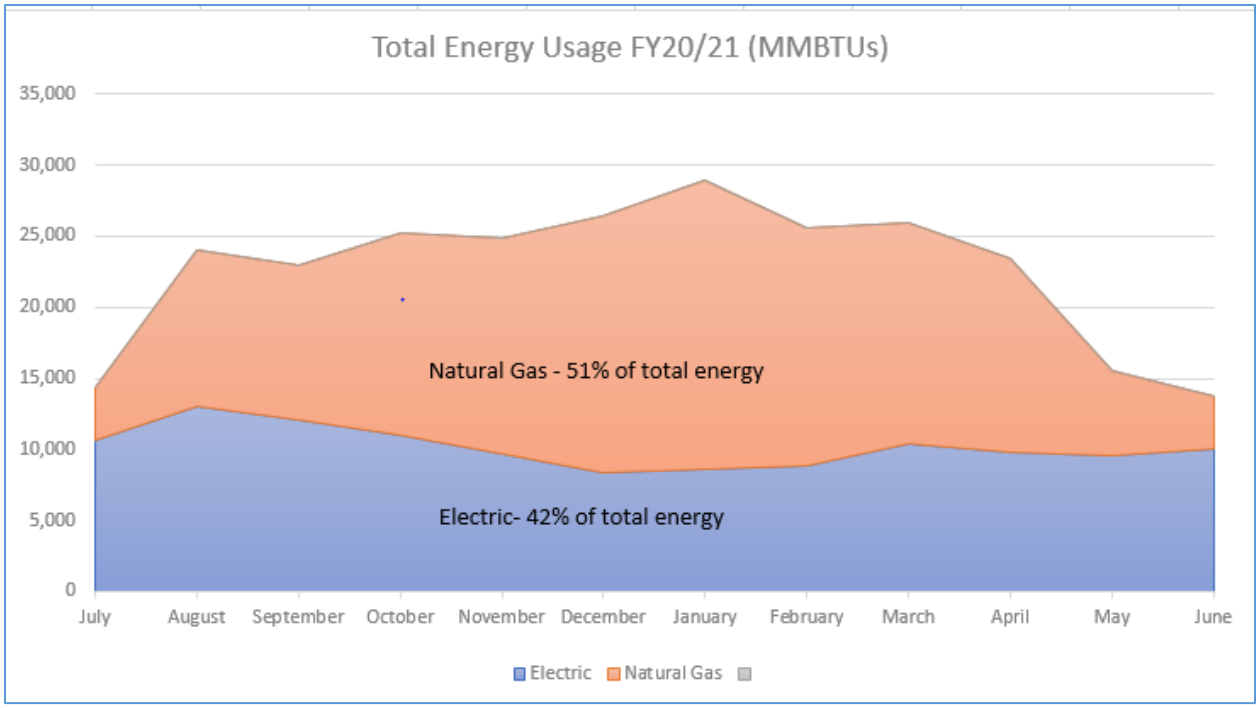
- Replaced failed controller on air handler three at Stillwell before Christmas. With the new controller, we can now un-occupy the entire academic wing of Stillwell which was previously running 24/7. This has reduced usage by approximately 10% for an avoided cost of around $10,000.

- Worked with design engineers, commissioning agents, and controls contractors over the past 5 years on the HVAC and lab ventilation systems at the Apodaca Science Building. The most complex building on campus is finally online and utilizes an energy recovery loop to recover thermal energy exhausted by the laboratories to preheat or precool incoming air.

- Total Utilities for FY20/21 - $3.5 million (electric - $2.3 million ; natural gas - $736,000 ; water - $356,000)

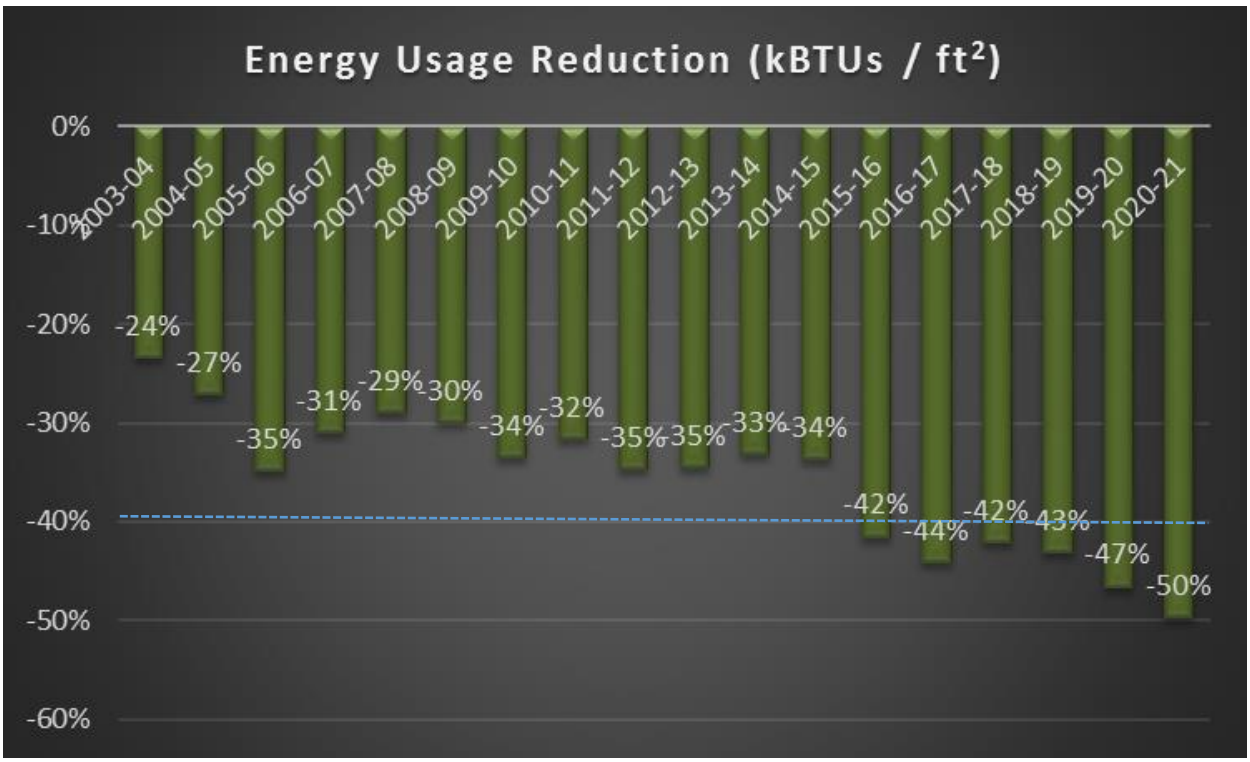


Electricity accounts for two-thirds of all utility costs…..



However, electricity is less than half of total energy usage; more financial savings by reducing electricity, but more energy savings by reducing natural gas usage. Electric usage does not account for source usage and inefficiencies.

FY20/21 Usage



WCU currently stands at a 50% reduction in energy usage intensity (EUI or how much energy we use per square foot of campus) compared to the baseline year of 2002-2003 and continues to exceed the State Energy Office's Utility Savings Initiative of 40% by 2025. Certainly, COVID has contributed to this year's reduction, typical electric bills for campus were down 25% starting in April of 2020 (see Addendum for long-term energy trends starting on p.23).

To reduce campus EUI by just 1% requires a reduction of 6 billion British Thermal Units or BTUs (1 match represents the equivalent energy in 1 BTU). For perspective, that's roughly the same reduction as 1,800,000 kWh (over $100,000 in electrical usage) or 60,000 therms (almost $30,000 in natural gas).

Overall campus electric demand (kW) is also trending downward despite a 25% increase in building square footage and an additional 4,000 students (40% increase) since FY2005/2006. The graph below is compressed to show 12 months which can exaggerate trends and doesn't factor weather, but in general the overall monthly demand is trending downward before and after COVID (e.g. for April-June the uptick in electric demand since students and staff have returned is still lower than in previous years).

The highest peak demand of 8,640 kW was back in August of 2013 (monthly cost of over $300K). For perspective, if the average person can maintain 100 watts on a bicycle, it would require 86,400 people (pedaling) to meet a campus demand of 8,640 kW.

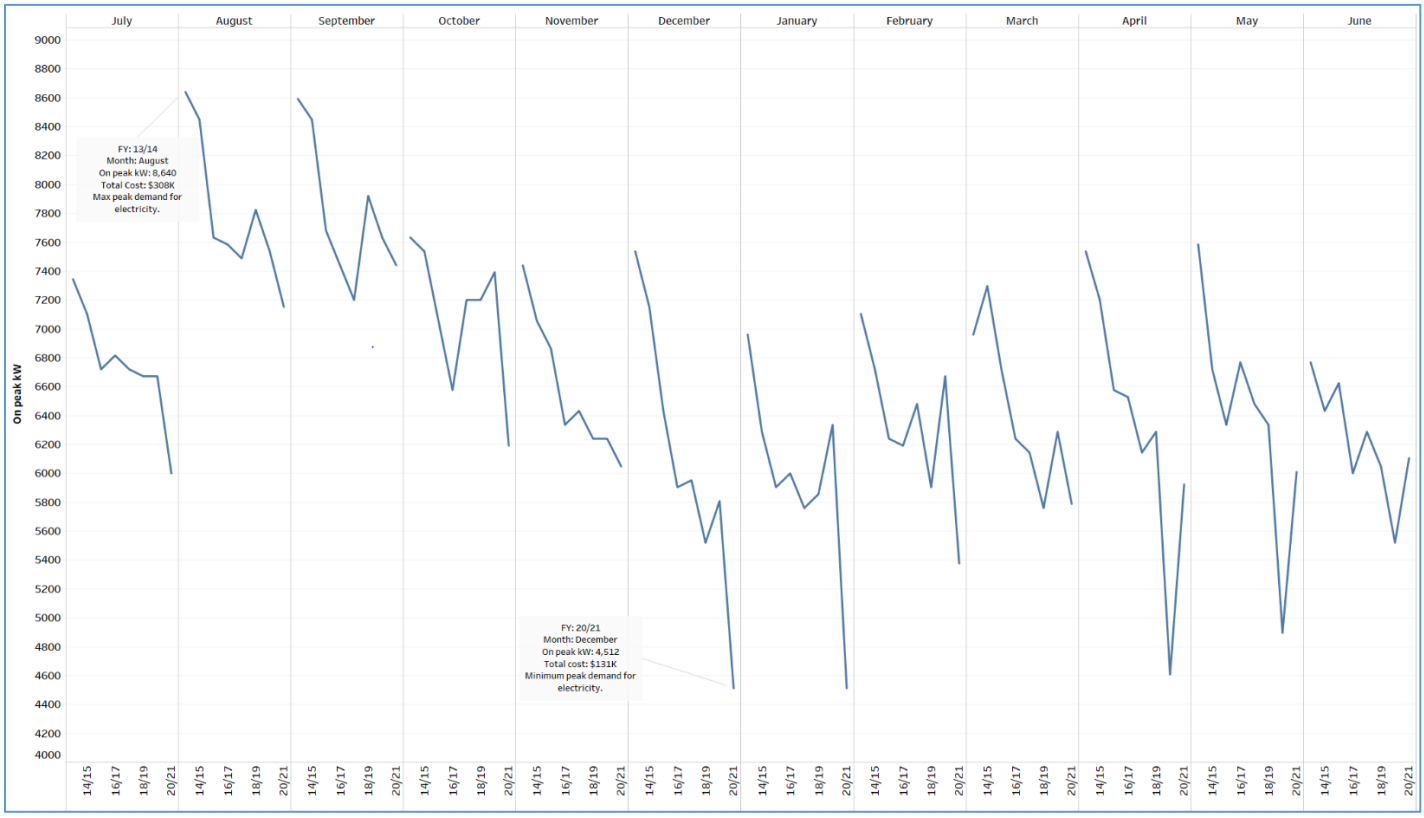


Tableau graph courtesy of Nathan Hodges and Alison Joseph

Building Usage

Of the 40 largest buildings on campus, five account for almost 25% for all utility costs (energy and water), the top 15 buildings account for 50% of campus utilities. Continued focus on the top tier of the most expensive buildings will yield the greatest financial, energy, and CO_2 savings.

Building	Built / Last Major Renovation	Utility Cost	% of Campus Cost
Hunter Library	1982	$ 260,628	6.4%
Ramsey Arena Center	1986	$ 194,446	4.8%
Health and Human Sciences	2012	$ 177,389	4.4%
Belk Building*	1971	$ 166,567	4.1%
Stillwell Science Building	2008	$ 166,406	4.1%
Bardo Arts Center*	2004	$ 165,592	4.1%
Courtyard Dining Hall*	2009	$ 151,939	3.7%
Natural Science Building	1977	$ 140,015	3.4%
Coulter Building	1978	$ 110,326	2.7%
Balsam Residence Hall	2009	$ 97,222	2.4%
Allen Residence Hall*	2019	$ 92,092	2.3%
Campus Rec Center	2008	$ 86,772	2.1%
Brown Dining Hall	2017	$ 85,776	2.1%
Hinds University Center*	1968	$ 79,010	1.9%
Albright-Benton Residence Hall	1962	$ 69,613	1.7%

Top 5 buildings represent 24% of campus utilities $965,436

Top 15 buildings represent 50% of campus utilities $2,043,792

**meter data incomplete due to steam condensate leak or electric meter failure*

"Bigger targets = bigger opportunities" – *Patrick Richardson*

Opportunities and status of the top 10 most expensive buildings are as follows:

- **1) Hunter Library - $260,628** – Previously Hunter Library had a total utility cost over $300,000, a second portable meter found the steam data to be suspect, replacement of the existing steam condensate line is pending. A BAS upgrade of the chiller plant along with BTU meter upgrades have reduced usage on that plant by 50% and saved over $30,000 in the first six months (see page 16 for details). A major renovation of the building mechanical systems is needed. Last major renovation was 38 years ago, in 1982.

- **2) Ramsey Arena Center – $194,446 -** With the third phase of the VFD / BAS controls upgrade complete, Ramsey has an avoided electrical cost of over $100,000 to date (page 20). Phase 4 and 5 will include replacing the pneumatic controls on the concourse and office areas.

- **3) Health and Human Science Building – $177,389 -** Despite housing an anatomy lab, campus servers, multiple hoods, and a PT clinic with therapy pool, HHS operates at an ENERGY STAR level for an office building (25th percentile of energy usage compared to similar building stock). This performance is due to a building tune-up project initiated in 2015 along with the implementation of scheduling software (Events2HVAC) to heat and cool spaces as needed using the 25Live schedule. Continued vigilance is still needed to maintain the 30% reduction and $50,000 in annual savings. The oversized chiller and needs of the Anatomy Lab also require monitoring to balance dehumidification and prevent over-cycling of the chiller. Post-COVID (when…?), an additional 20-30% could be saved by un-occupying non-critical areas over the weekends during spring, fall, and winter (reducing operating days from 7 to 5 days a week).

- **4) Belk Building – $166,567 -** Built in 1971, Belk would need a major mechanical renovation to achieve significant energy savings. Improved scheduling has already reduced run hours by 30%. Cost above is prior to scheduling adjustment, building meter failed one month after adjustment. While a new meter has been installed, additional configuration is still needed.

- **5) Stillwell Science Building – $166,406 -** This building is scheduled for a partial backfill once the Apodaca Science Building is completed as some of the existing hoods will be removed as classes move to Apodaca. The recent emergency replacement of the controls on air handler 3 has allowed us to un-occupy the academic wing which was previously running 24/7. To date, this has reduced usage by approximately 10% for an avoided utility cost of around $10,000.

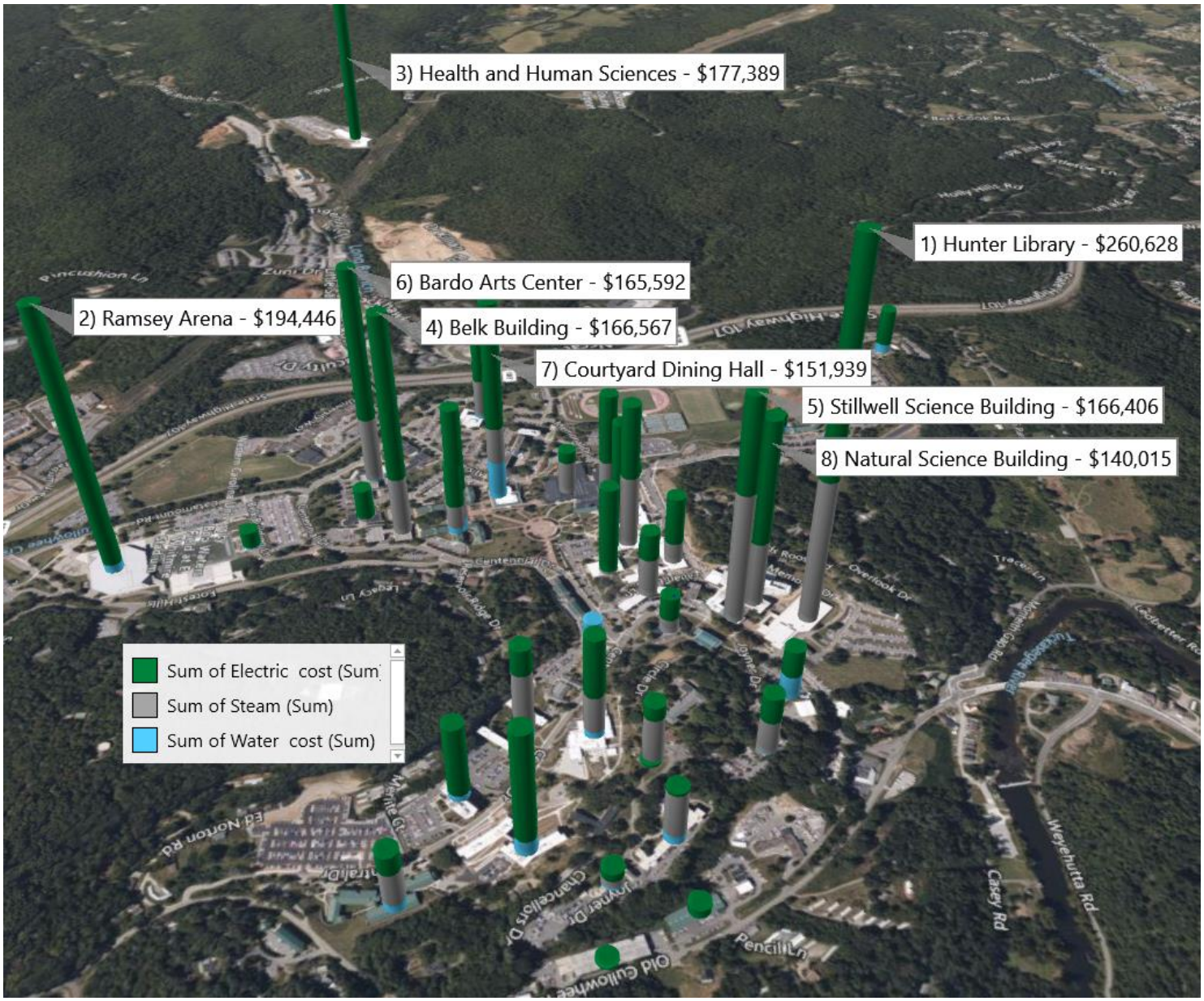
- **6) Bardo Arts Center** – **$165,592 -** BAS upgrade to just the Museum took place in 2019 to help improve the humidity control necessary for accreditation (many museums and collections require a history of temperature and humidity control before loaning out works of art). While additional programming software and training was purchased to initiate a building tune-up, progress continues to be slow. While completed in the early 2000's the BAS technology is from the late 90s and is cumbersome to work with even for experienced vendors (if you can imagine meeting your current office demands while still using Windows 95). Maintenance contract with BAS vendor will focus on continuing the building tune-up. By simply running the Theatre HVAC for events only (previously running 7am-10pm) has saved over $12,000 a year (over $60,000 to date).

- **7) Courtyard Dining** – **$151,939 -** The most expensive building per square foot on campus. The campus average for utilities is less than $1.00 /ft^2 while Courtyard is over $4.00 / ft^2 (in fairness it is a dining hall, however, it's energy usage intensity is still above the nation median value for dining halls). A feasibility study is still needed to see if make-up air can be provided directly to the existing kitchen hoods. Currently all make-up air for the kitchen area is conditioned air (heated and cooled) provided by the building's two air handlers (instead of make-up air at the kitchen exhaust). This creates comfort issues when hot, humid outside air must be conditioned and supplied to the kitchen, in addition to the full load created by occupants. A BAS upgrade is also on the horizon.

- **8) Natural Science Building – $140,015 -** built in 1977, scheduled for demolition in 2021. Despite having 21 buildings on campus larger than NSB, it was fourth on the list for using the most steam of any building on campus last year, demonstrating how energy intensive an inefficient science building can be.

- **9) Coulter Building – $110,326 -** Built in 1978, the current HVAC system is all pneumatic and requires a major renovation.

- **10) Balsam Residence Hall – $97,222 -** Balsam is in the top 10 as it houses a chiller plant for both itself, Blue Ridge Residence Hall, and Courtyard Dining. While Courtyard chilled water usage has been accounted for, further refinement is needed to separate chilled water usage from Balsam and Blue Ridge. Opportunities to un-occupy (relax the cooling setpoints) for the majority of the rooms exist over the summer when the building is used periodically for conferences. This opportunity also exists for Blue Ridge and Harrill Residence Halls and only requires minor coordination to arrange, as it can be done remotely.



Utility costs totaled– Excel 3D maps

Focus for FY2020/2021

- Continue to replace building automation systems (BAS) greater than 15 years of age that no longer have building level controllers available or whose database cannot be supported with campus migration to latest version of Windows server. Capture associated energy savings with House Bill 1292 to fund future BAS upgrades (which has grown from $22,000 in FY13/14 to over $229,600 in FY20/21)
    - Implement phase 4 of BAS upgrade at Ramsey Arena; replace original pneumatic controllers on the two air handlers and 40 plus zone controllers serving the Concourse; replace pneumatic controls on the auxiliary gym.
    - Review the existing BAS system at Bardo Arts Center and obtain quotes for phased upgrade.
    - Replace the aged pneumatic system on steam heat exchanger at Reid Gym.

- Provide support for the HVAC, lab ventilation, and energy recovery loop at the Apodaca Science Building (an additional 2,400 points of data to manage). This building continues to require a large amount of time to fine-tune and to establish the baseline performance of the lab ventilation system (i.e. snapshot of the current system capacity so we can monitor for degrade over time).

- Roll out weekend schedule on 11 academic buildings which currently run all weekend regardless of occupancy (estimated savings of $100,000). A rough estimate shows a potential CO_2 reduction of 5% needed toward Executive Order 80. – *Rollout delayed due to COVID- 8/26/21*

- Create video content on Building Tune-Ups as part of the UNC Energy Managers sub-group.

- Refine existing alarm management program within the BAS to only generate alarms on primary equipment (chiller, boilers, air handlers) that need immediate response from HVAC shop.

- Install ultrasonic meter at Balsam cooling towers, currently un-metered. Estimated $5,000 - $6,000 in potential annual avoided sewer charges based on other cooling tower data. This has been on the list for a few years, but is usually de-prioritized as more immediate issues come up on campus (e.g. mechanical / controls failures, humidity control issues, COVID).

This will be in addition to maintaining daily operations on over 2.2 million ft^2 of BAS systems and 180 electric and water meters across campus.

Executive Order 80

year	gsf	gsf % change	construction gsf	Students	Students % change	CO2 lbs. kWh	CO2 lbs. NG therms	CO2 lbs. #2 Oil	CO2 lbs. #6 Oil	CO2 lbs. Propane	CO2 lbs. Total	CO2 % change
2005-06	2,734,121		14,655	8,665		68,538,629	5,257,404	759,830	20,029,542	320,510	94,905,915	
2006-07	2,843,308	4.0%	0	8,861	2.3%	65,882,093	20,665,539	731,002	3,817,034	357,454	91,453,121	-3.6%
2007-08	2,790,749	2.1%	0	9,056	4.5%	65,006,558	23,934,327	625,231	92,014	302,945	89,961,075	-5.2%
2008-09	2,863,949	4.7%	0	9,050	4.4%	66,456,162	23,750,925	809,899	765,050	1,114	91,783,149	-3.3%
2009-10	2,798,946	2.4%	0	9,429	8.8%	69,653,626	20,087,158	588,213	195,000	382,213	90,906,210	-4.2%
2010-11	2,911,228	6.5%	0	9,407	8.6%	69,937,987	22,517,452	1,010,464	78,000	335,979	93,879,881	-1.1%
2011-12	2,954,814	8.1%	0	9,352	7.9%	71,157,749	21,109,898	884,995	0	313,850	93,466,492	-1.5%
2012-13	3,105,538	13.6%	0	9,608	10.9%	73,898,717	22,768,116	523,248	26,000	357,638	97,573,720	2.8%
2013-14	3,103,210	13.5%	0	10,107	16.6%	74,817,034	21,782,005	442,225	2,548,468	389,486	99,979,218	5.3%
2014-15	3,103,210	13.5%	0	10,382	19.8%	73,486,895	22,803,832	501,939	1,040,000	269,582	98,102,247	3.4%
2015-16	3,103,210	13.5%	0	10,340	19.3%	67,959,905	19,803,062	471,363	52,000	316,827	88,603,157	-6.6%
2016-17	3,223,781	17.9%	120,571	10,805	24.7%	67,853,607	19,649,696	534,038	52,000	153,929	88,243,271	-7.0%
2017-18	3,282,381	20.1%	58,600	11,034	27.3%	66,301,919	22,128,996	510,720	52,000	172,493	89,166,128	-6.0%
2018-19	3,282,381	20.1%	0	11,639	34.3%	65,906,644	21,543,836	545,552	52,000	108,908	88,156,939	-7.1%
2019-20	3,447,994	26.1%	165,613	12,167	40.4%	63,909,231	18,813,075	443,363	4,241,250	84,734	87,491,654	-7.8%
2020-21	3,234,681	18.3%	0	12,243	41.3%	60,021,495	18,014,957	646,195	0	124,572	78,807,219	-17.0%
2021-22	0		0									
2022-23	0		0		*North Carolina's greenhouse gas (GHG) emissions goal under EO80 is to reduce emissions by 40% from*							
2023-24	0		0		*all economic sectors by 2025.*							
2024-25	0		0									

1.559 lbs CO_2 / kWh
11.71 lbs CO_2 / CCF or 1 therm
22.4 lbs CO_2 / gallon of #2 oil
26 lbs CO_2 / gallon of #6 oil
12.7 lbs CO_2 / gallon of propane

https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references
https://www.eia.gov/environment/emissions/co2_vol_mass.php
https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

The Governor's Executive Order 80 calls for a 40% reduction in CO_2 emissions compared to a base year of 2005. WCU is currently at a 17 % reduction which due to COVID is an artificial number. This is based on total energy consumption and emissions instead of energy or CO_2 per square foot. Campus square footage and student enrollment have grown 25% and 40% respectively, since the baseline year in 2005. Many universities that in good stewardship have pledged to be CO_2 neutral by 2030 or 2040 are not close to meeting this goal. Of the 450 colleges and universities that pledged to be carbon neutral only seven have reached carbon neutrality and all seven used carbon offset purchases (Second Nature, 2020).

However, there are cost effective opportunities to reduce emissions, save on utilities, and extend the life of mechanical equipment. *How then do we prioritize resources, both time and fiscal?* Below is list of executed projects on campus along with their financial and emissions impact. The last column shows the pounds of CO_2 reduced per dollar spent on project in order of the most cost effective to least.

Project	Description	Annual Savings	Investment	Savings to Investment Ratio (SIR) or ROI	Simple Payback (years)	Total Reduction CO2 Lbs.	Cost effectiveness CO2 Reduction Lbs. per dollar spent
Campus Scheduling	unoccuping weekends for non	$ 100,000	time		immediate	4,000,000	very
Events to HVAC	Space scheduling software	$ 23,110	$ 5,013	461%	0.22	418,933	83.6
HHS Re-tuning	Optimization and calibration c	$ 30,000	$ 30,996	97%	1.03	623,600	20.1
Steam meter upgrade	Campus-wide upgrade to ultra	$ 127,059	$ 230,400	55%	1.81	n/a	n/a
Ramsey VFD install	Added VFDs to 25 air handlers	$ 25,000	$ 250,000	10%	10.00	593,904	2.4
LED campus upgrade	Performance contract*	$ 219,228	$ 3,300,000	7%	15.05	4,925,749	1.5
Solar installation	10 kW	$ 900	$ 25,000	4%	27.78	14,776	0.6

**LED savings compare 12 months prior and post installation and do not include maintenance savings ; solar installation cost does not include structural cost for solar lounge which are unique*

One of the greatest opportunities not yet executed would be to relax heating and cooling setpoints on the weekends in non-critical areas of 11 academic and office buildings (e.g. Forsyth, Belk, Killian, Killian Annex, Bardo, Breese, McKee, CAT, HFR, Old Student Union, and HHS). This would involve coordination to identify critical areas (e.g. radio station at Old Student Union), but simply going from running equipment 7 days a week to 5 days is a 28% reduction in run time and associated emissions for a potential avoided cost of over $100,000 and a campus reduction of another 5% or 4,000,000 lbs. of CO_2 (see pg. 27 for calculation).

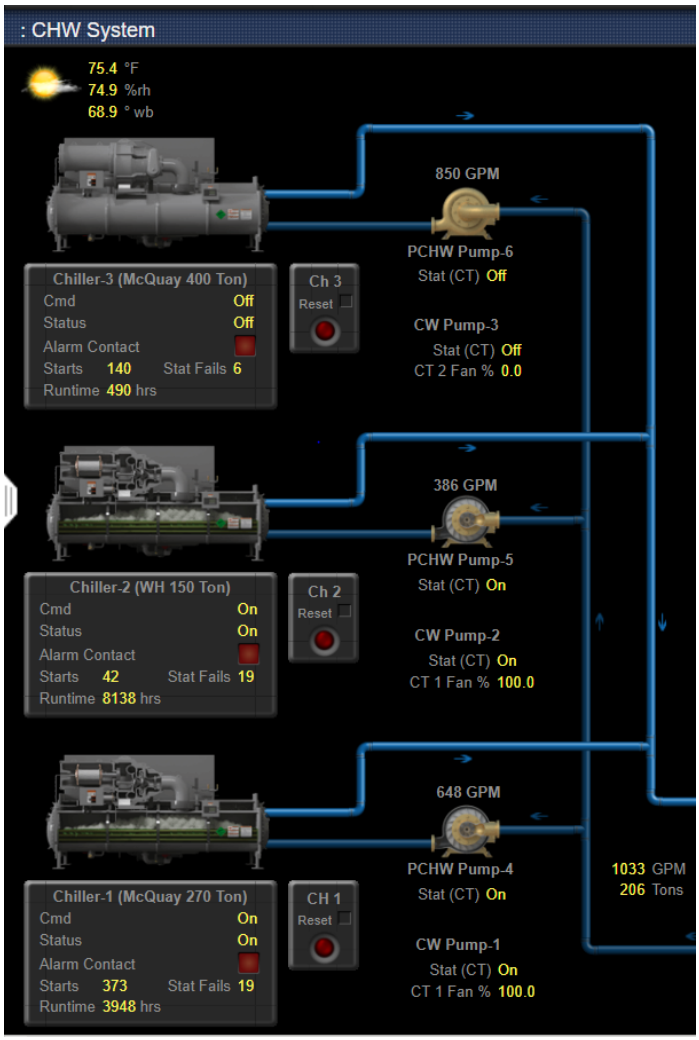
For buildings with newer BAS systems, if weekend or after hours' events are in 25Live (classroom scheduling software), that schedule can be pushed down to the building level controllers with third party software (Events2HVAC). This already has a successful track record as demonstrated at HHS (see cash flow chart on pg. 21). One of the best complements came from Dean Keskula who when asked many months later about the project had forgotten about the installation of Events2HVAC. This is more than understandable given his responsibilities, but demonstrates how such projects can be executed with minimal disruption. Staff there were consulted before proceeding and critical areas such as server rooms and laboratories were excluded from the project.

CO_2 sensors are used across campus to monitor indoor air quality and to increase outside air when levels increase. A typical range is around 400 parts per million (ppm). When converted to a percentage this is 0.04 % or 4 one-hundredths of 1 percent. This is compared to 78% nitrogen and 21% oxygen that comprise the air we breathe. This small trace amount is what regulates heat in the atmosphere.

Due to continued COVID concerns the implementation of campus weekend scheduling has been delayed.

While solar and renewables dominate the discussion in the media, they have a low amount of savings and emissions reduction on campus (as seen above) given our low commercial utility rates and exemption from federal and state credits. This should not be interpreted as an attack on renewables as they are robust technologies (25-year warranty is standard on most solar panels), however if we are looking to achieve the greatest fiscal savings and reductions in emissions we need to prioritize our projects and resources. Therefore, we approach in the order of conservation, efficiency, and then renewables.

Hunter Library Chiller Plant Controllers Upgrade

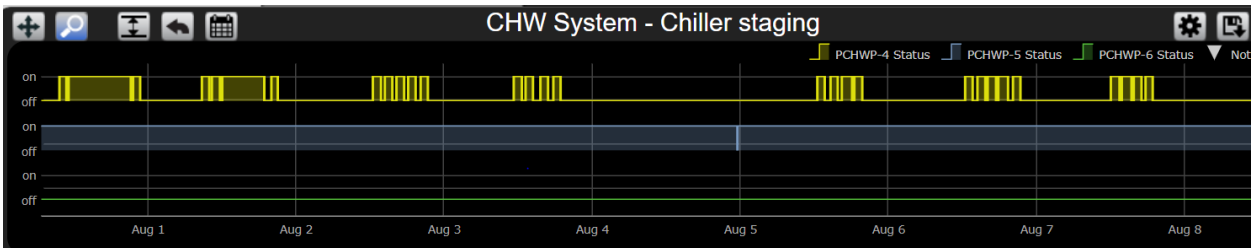


The chilled water plant at Hunter Library provides chilled water for building cooling to Hunter, Stillwell, Hoey, and McKee and was a concern considering the existing control system was at its end of life.

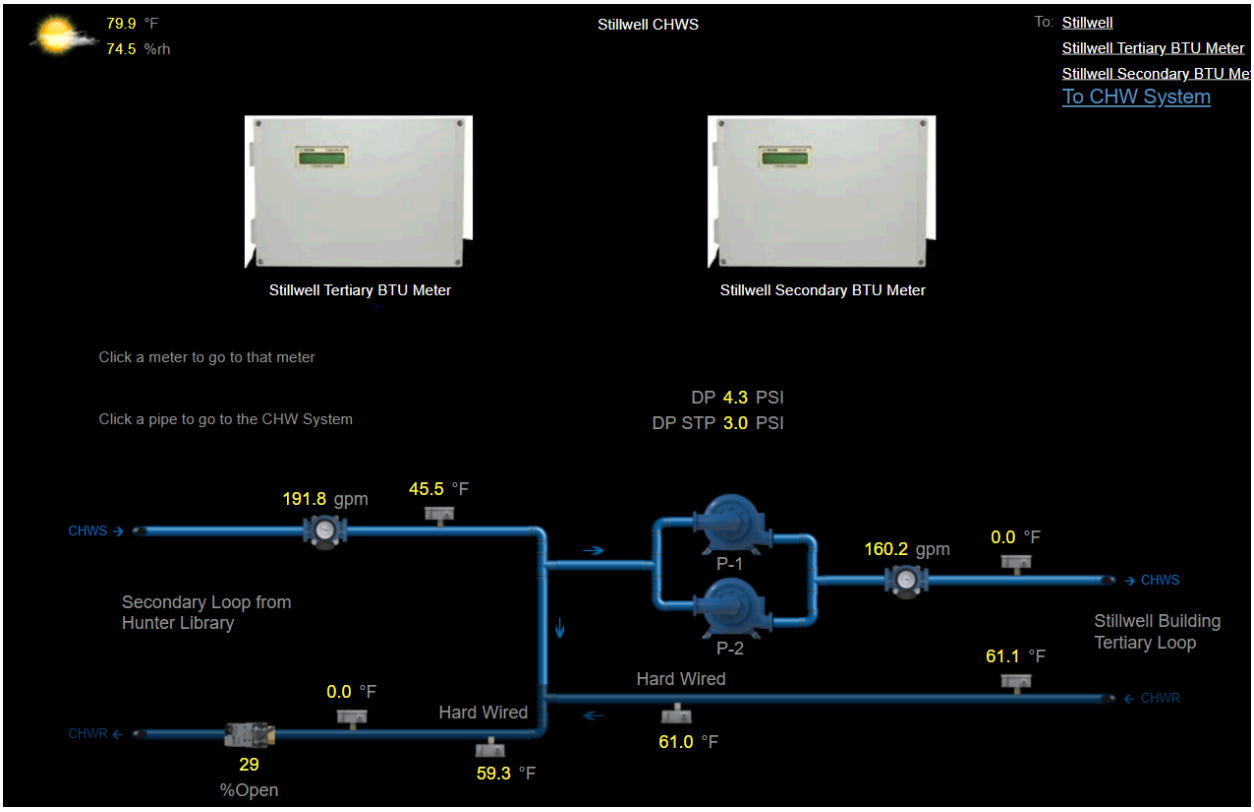
By February of 2021, we had upgraded not only the controls system, but had integrated BTU meters on each branch of the system in order to determine what was driving demand by building. This led to the discovery of a few suspect hot water valves on the air handlers on the West wing of Hunter Library. The aged pneumatic lines were either failing to provide adequate pressure to keep the hot water valves closed or had been manually set to provide comfort during the winter months.

Unfortunately, a complete renovation of the HVAC system at Hunter is needed to completely resolve these issues that are creating a false heating load that requires running the chillers even during winter months. The 1950's pneumatically controlled air handlers are also unable to properly economize or control available outside air for cooling.

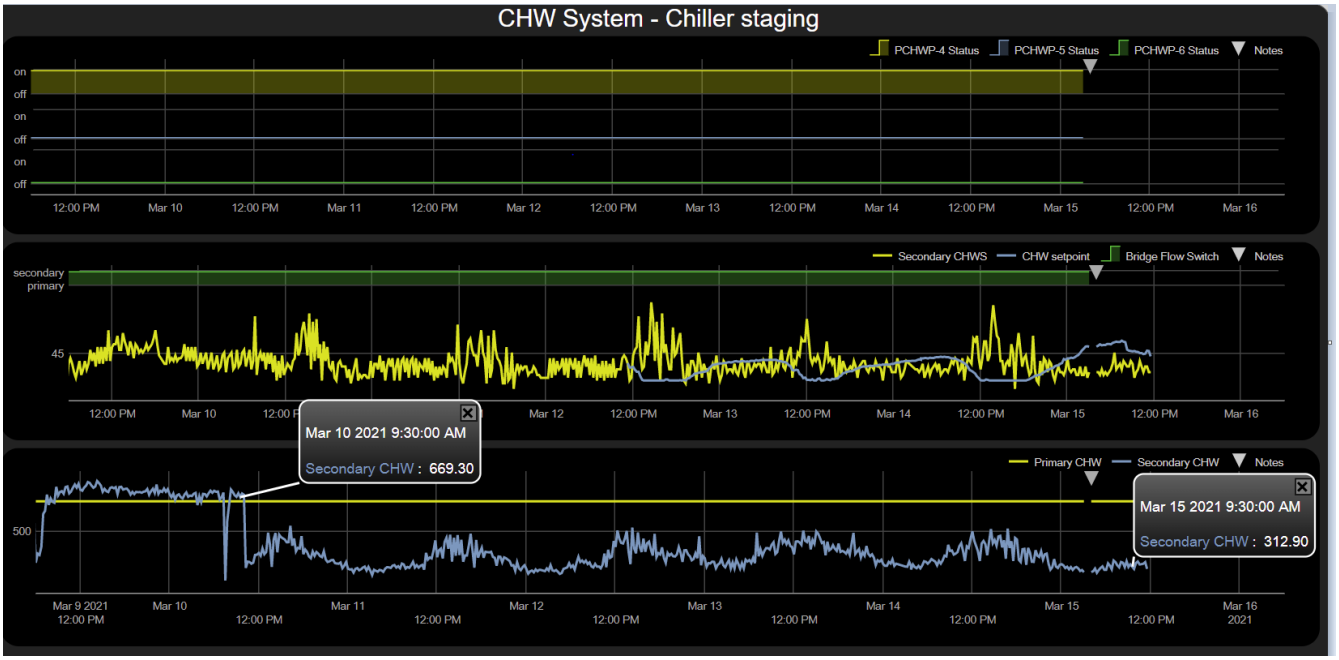
However, despite these discoveries we have been able to reduce usage there by almost 50% for an avoided electric savings of over $30,000 in just six months. After consulting with the chiller service technician, we scheduled the smallest to largest chiller to run in that order to meet the demand from the buildings. Even in the first week of August we are able to meet demand by running the smallest chiller (150 Ton - blue trend below) as the baseload and have the middle-sized chiller (270 Ton – yellow trend) come on-line a few times daily as needed. Note the largest chiller (400 Ton – green trend) has not enabled a single time during this period. On the older control system it was not uncommon to see all three chillers running.



By reviewing the existing system with the original engineer of design we also discovered that the 1990's control system at Stillwell was not operating as intended. We were able to meet the design intent by adding a BTU meter to monitor the chilled water demand at Stillwell and a meter on the branch supplying chilled water to Stillwell. In the screen capture below the building demand at Stillwell is 160.2 gpm which we are able to provide and slightly overflow at 191.8 gpm by controlling the bridge valve to the building to open to 29%.



The previous system was controlling by comparing return temperatures and was providing twice as much chilled water as needed. This excessive amount of chilled water was then returned to the chiller at a temperature much less than design which reduced the cooling capacity of the chiller and in some instances would require an additional chiller to run. On the screen capture below, note the drop in demand on the entire system from 600 gpm to 300 gpm on March 10th once the new program at Stillwell was downloaded.


CHW System - Chiller staging
PCHWP-4 Status
PCHWP-5 Status
PCHWP-6 Status
Notes
on
off
on
off
on
off
12:00 PM
Mar 10
12:00 PM
Mar 11
12:00 PM
Mar 12
12:00 PM
Mar 13
12:00 PM
Mar 14
12:00 PM
Mar 15
12:00 PM
Mar 16
Secondary CHWS
CHW setpoint
Bridge Flow Switch
Notes
secondary
primary
45
Mar 10 2021 9:30:00 AM
Secondary CHW : 669.30
Primary CHW
Secondary CHW
Notes
500
Mar 15 2021 9:30:00 AM
Secondary CHW : 312.90
Mar 9 2021
12:00 PM
Mar 10
Mar 11
Mar 12
Mar 13
Mar 14
Mar 15
Mar 16
2021

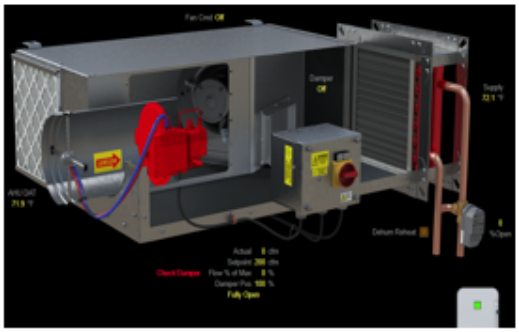
Project Cash Flow Summaries

Project - HFR BAS upgrade

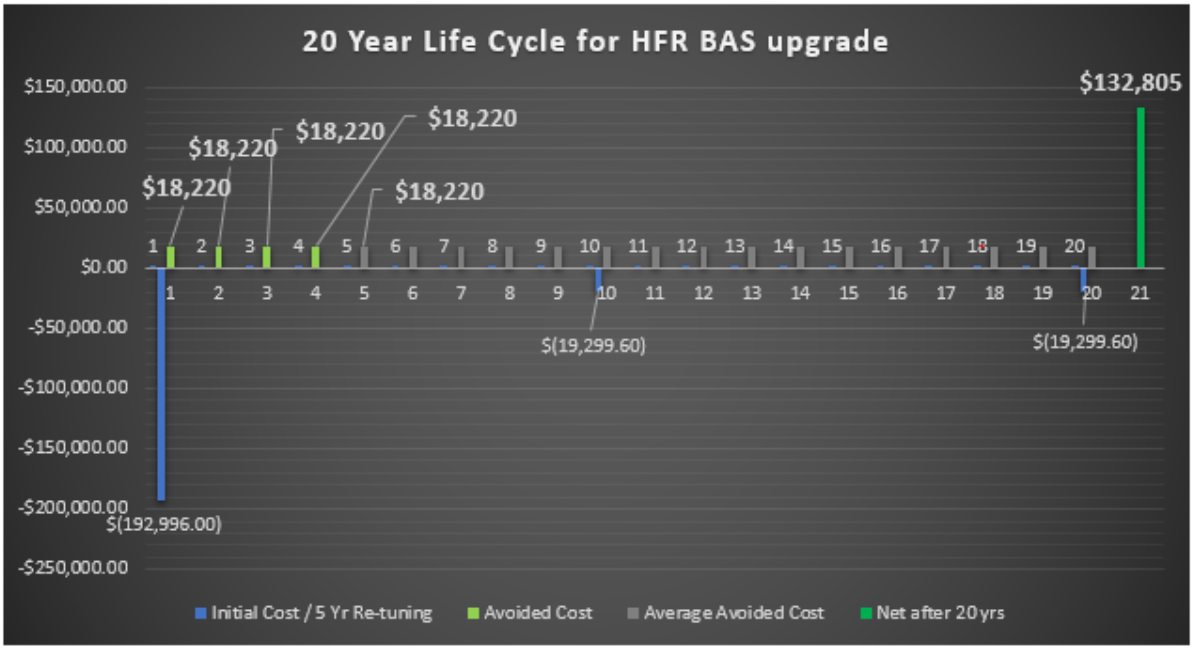
Initiated : 2/24/2020

Replaced existing 1990's building automation system at the HFR administration building. Reduced electrical usage by 30% ($15,523) and steam usage by 9% ($2,696), savings likely exaggerated by COVID, However, additional scheduling opportunities have been implemented that are not yet realized.

Initial Cost	$	192,996	
Annual Savings	$	18,220	
Savings to Date	$	18,220	*1 yr*
Simple payback		10.6	*yrs*
ROI		9.4%	
Net - 20 Year Life Cycle	$	132,805	



Typical fan coil at HFR



- *One year savings of $18,220 used to estimate 20 year cash flow*
- *10 % of initial cost used to estimate reoccuring replacement costs*

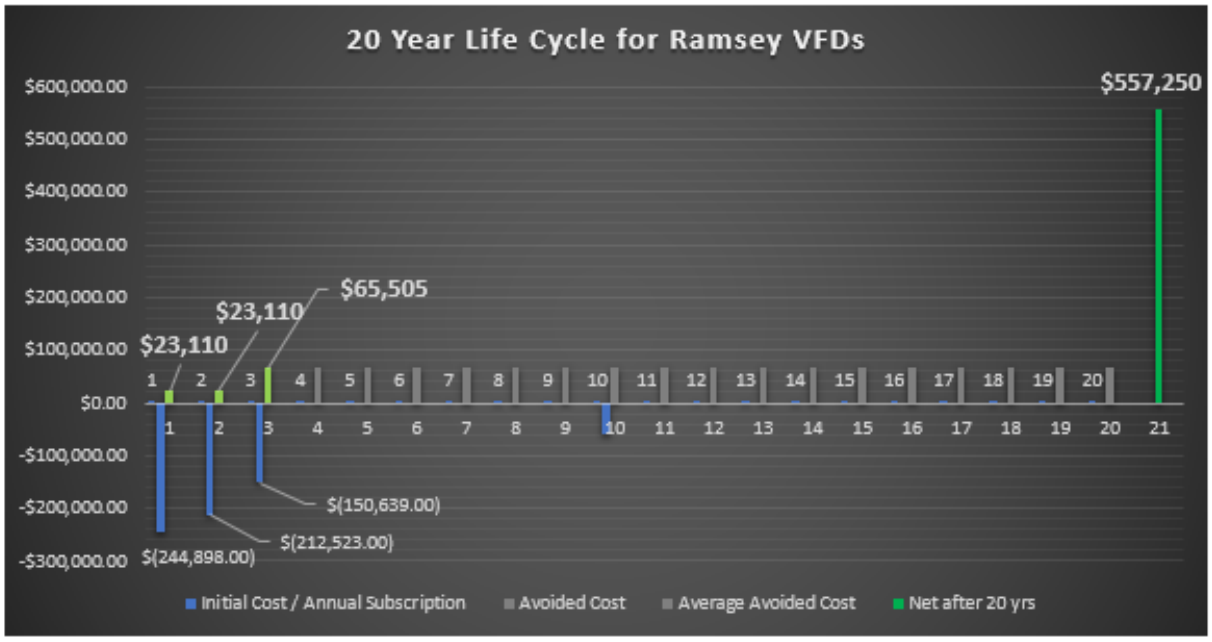
Project - Ramsey Arena - VFD & BAS installation **Initiated : May 2019**

Variable Frequency Drives (VFDs) have been added to the 25 existing air handlers at Ramsey as part of a necessary controls upgrade. Reducing the speed on single zone air handlers from 60Hz to 40Hz not only saves energy, but reduces wear and tear on equipment.

Phase 1 of BAS controls upgrade ; savings achieved by manually lowering drive speeds on 12 single zone AHUs.

Phases 2 and 3 have involved replacing original controllers and valves on the Arena air handlers and adding control to the chiller and boiler plants

Cost to date	$ 608,060	
Annual Savings	$ 65,505	
Savings to Date	$ 111,725	*3 yrs.*
Simple payback	9.3	*yrs*
ROI	10.8%	
Net - 20 Year Life Cycle	$ 557,250	



- Year 10 - 10% replacement cost ($60,000) used to estimate 20 year cash flow

Project - Health and Human Science Building - Events2HVAC **Initiated : 10/9/2018**

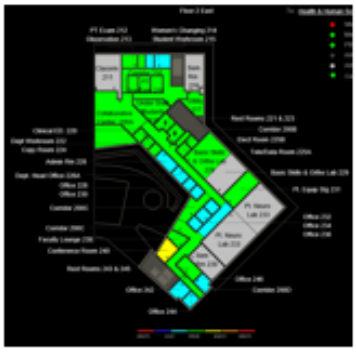
Updated 10/18/2019

Events2HVAC was implemented in October of 2018 and has reduced energy usage 12% in the first 12 months. The Health and Human Science Building is now at ENERGY STAR level for an office building (25th percentile of energy usage compared to similar building stock) which is noteworthy considering it houses an anatomy lab, campus data servers, mutiple kitchen and fume hoods, and a PT clinic with hydrotherapy pool. Events2HVAC takes the classroom schedule from 25Live and pushes it out to the individual controllers at the building level. The result is that classrooms are heated/cooled based on actual class schedule (i.e. 8am-10am and 1pm-3pm) instead of a general schedule at the building level (7am-11pm).

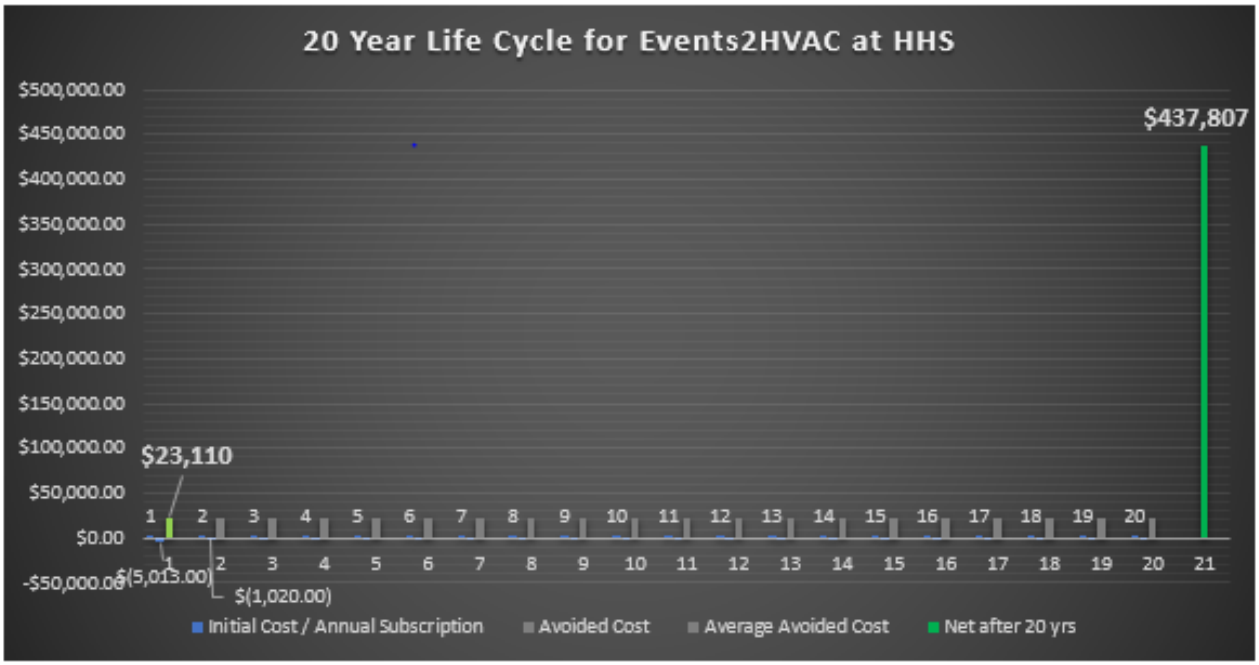
Initial Cost	$ 5,013	
Annual Savings	$ 23,110	*$0.086/kWh*
Savings to Date	$ 23,110	
Simple payback	0.2	*yrs*
ROI	461.0%	
Net - 20 Year Life Cycle	$ 437,807	

The 268,719 kWh saved would require $400,000 in solar panels to generate the equivalent energy (200 kW system installed at $2,000 a kW)

PVWatts.com



Unoccupied areas in gray



- Year one savings ($23,110) used to estimate 20 year cash flow

- Annual subscription fee of $1,020

Project - Campus-wide upgrade to ultra-sonic meters

Initiated : October, 2015

Completion : 31 of 32 buildings

Previously, condensate from steam was captured using turbine meters that couldn't withstand the caustic environment of the condensate that is returned from the building back to the steam plant. Ultra-sonic meters reside on the exterior of the pipe, don't require additional flanges or bypass piping, and can be installed without a steam shutdown.

Initial Cost	$	230,400	
Annual Savings	$	118,182	*4 yr avg*
Savings to Date	$	472,728	*4 yrs*
Simple payback		1.9	*yrs*
ROI		51.3%	
20 Year Life Cycle	$	2,110,200	

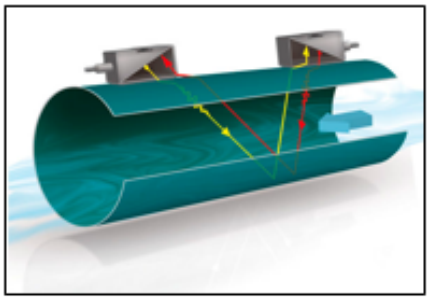
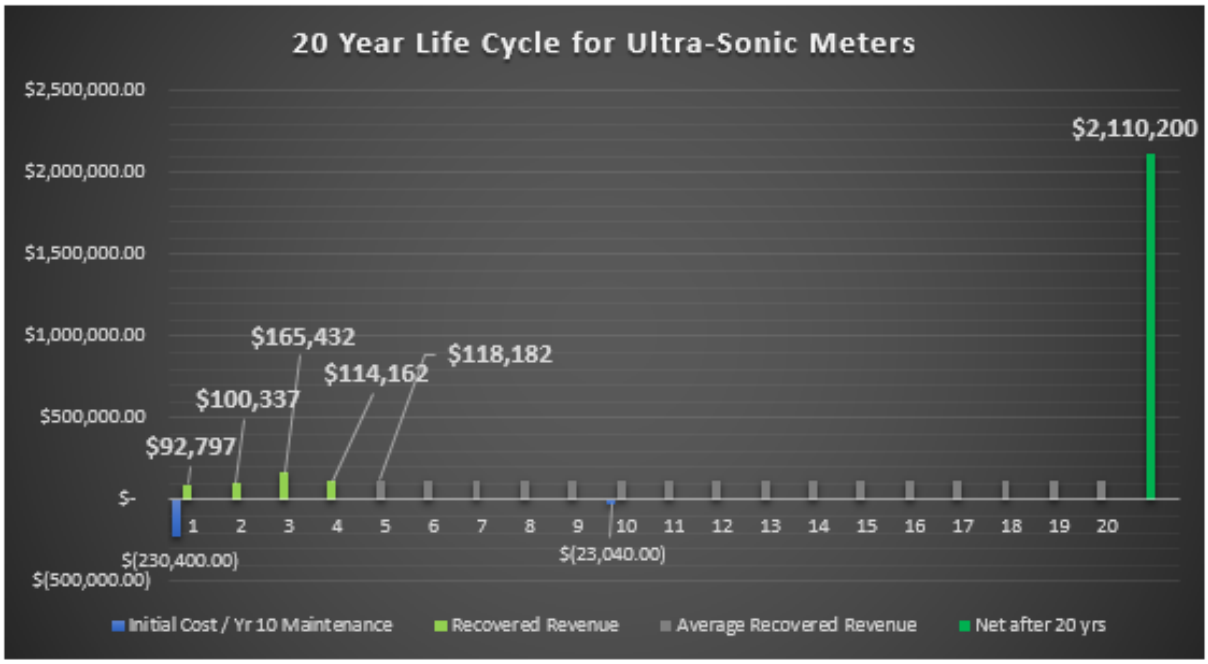


Image : Directindustry.com



- Four year average ($118,162) used to estimate 20 year cash flow

- 10 % of initial cost used to estimate Year 10 maintenance / replacement cost

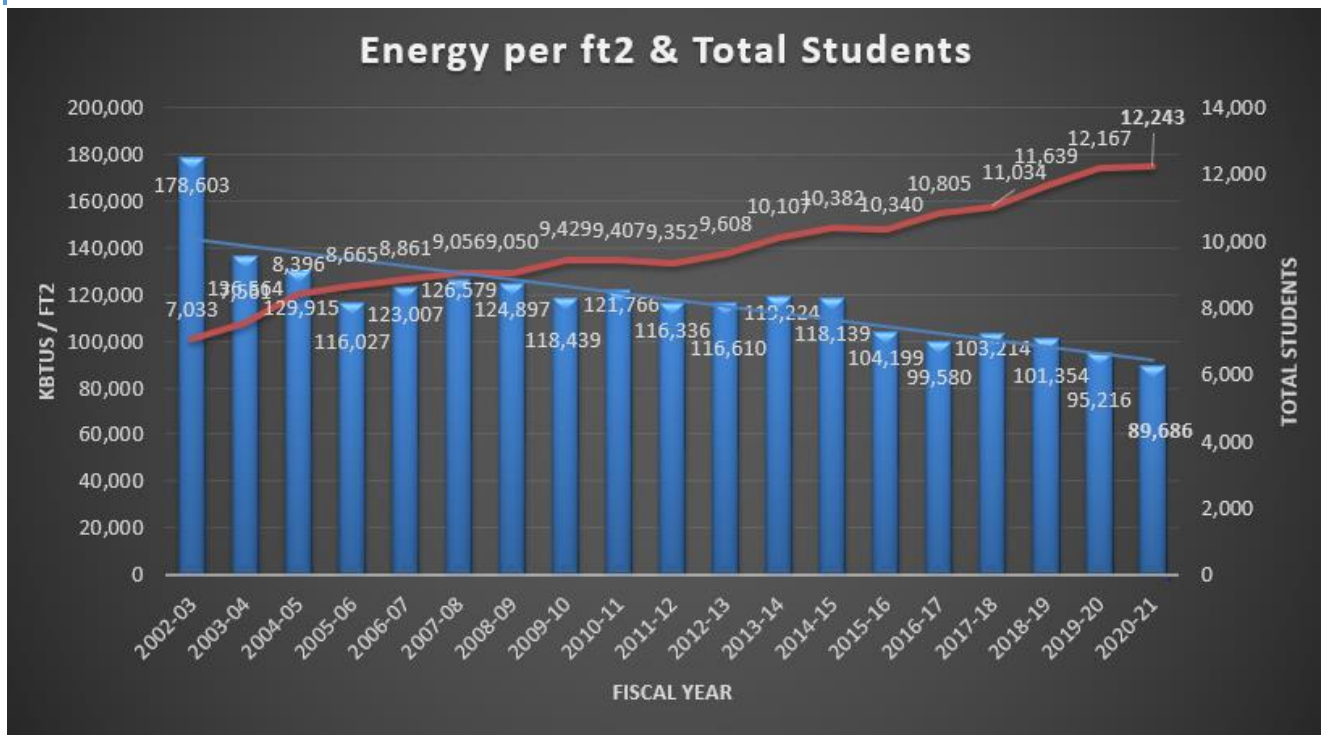
Addendum / Updated Data

1292 Carry Forward							
Project	FY15/16	FY16/17	FY17/18	FY18/19	FY19/20	FY20/21	Total to date
HFR renovation	$ 12,481	$ 12,673	$ 12,193	$ 12,193	$ 12,059	$ 12,155	$ 99,369
Make-up water savings	$ 15,118	$ 15,893	$ 10,297	$ 5,054	$ 5,380	$ 6,512	$ 69,520
Make-up water savings BTU savings	$ 25,806	$ 24,646	$ 14,949	$ 7,547	$ 8,223	$ 10,660	$ 115,403
HHS Savings	$ 10,786	$ 37,184	$ 41,533	$ 41,574	$ 57,991	$ 58,453	$ 247,520
Fine and Performing Arts		$ 12,640	$ 13,474	$ 10,494	$ 13,205	$ 13,510	$ 63,322
Belk AHU schedule			$ 3,710	$ 3,710	$ 3,710	$ 17,429.75	$ 28,560
Forsyth AHU programming			$ 6,233	$ 8,178	$ 8,878	$ 9,516	$ 32,806
Facilities Boiler replacement				$ 3,232	$ 3,112	$ 2,621	$ 8,965
Ramsey Arena VFD installation					$ 23,931	$ 24,122	$ 48,053
Ramsey Boiler/Chiller BAS						$ 41,383	$ 41,383
HFR BAS replacement						$ 18,293	$ 18,293
Stillwell AHU 3 BAS replacement						$ 6,066	$ 6,066
Hunter Library Chiller						$ 8,881	$ 8,881
	$ 64,191	**$ 103,036**	**$ 102,390**	**$ 91,982**	**$ 136,489**	**$ 229,602**	**$ 788,142**

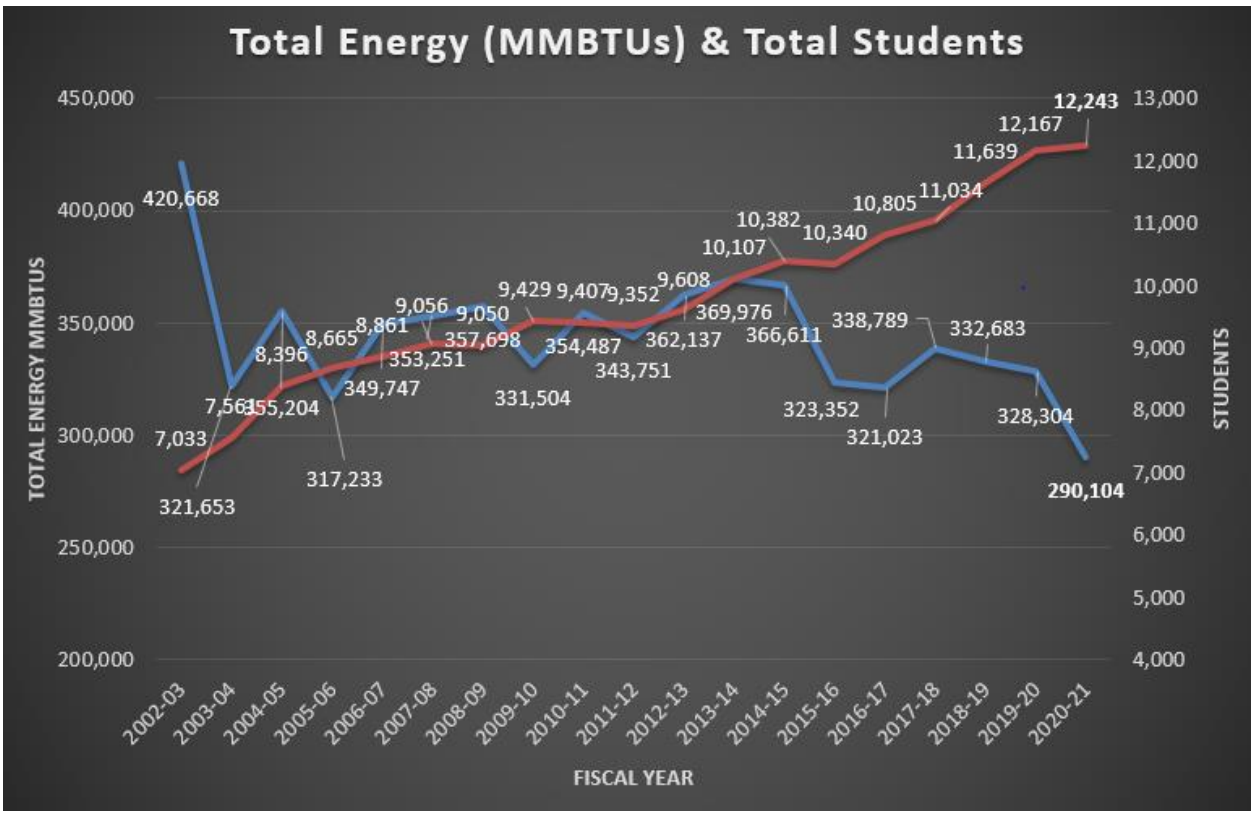
House Bill 1292 Energy Carry Forward Savings – additional projects have helped offset loss of previous condensate savings which were as high as $40,000 in FY16/17 down to $13,000 by FY19/20.

Recovered Steam Plant Operational Costs							
	FY15/16 (10 mont	FY16/17	FY17/18	FY18/19	FY19/20	FY20/21	Total to Date
Albright Benton	$ 16,978	$ 14,474	$ 15,752	$ 14,476	$ 22,051	$ 9,249	$ 92,981
Balsam	$ 7,659	$ 12,992	$ 15,306	$ 13,961	$ 28,845	$ 12,262	$ 91,025
Blue Ridge	$ 3,220	$ 1,244	$ 2,987	$ (1,240)	$ 1,843	$ 276	$ 8,331
Judaculla	$ 15,121	$ 19,248	$ 22,008	$ 20,616	$ 38,295	$ 11,562	$ 126,850
Courtyard	$ 37,841	$ 34,577	$ 50,434	$ 30,395	$ 30,452	$ 30,452	$ 214,151
Scott	$ (1,325)	$ (336)	$ (462)	$ (2,552)	$ (10,922)		$ (15,597)
Walker	$ 14,637	$ 15,453	$ 26,863	$ 18,170	$ 37,768		$ 112,890
University Center	$ (1,334)	$ (7,730)	$ 2,533	$ (7,401)	$ (13,279)	$ 1,466	$ (25,744)
Reynolds		$ 10,416	$ 20,736	$ 16,725	$ 20,661	$ 13,312	$ 81,849
Madison			$ 7,315	$ 9,668	$ 9,013	$ 10,860	$ 36,856
Robertson			$ 551	$ (3,796)	$ (7,482)		$ (10,727)
Bird			$ 1,409	$ 4,947	$ 5,318	$ 4,699	$ 16,372
Buchanan				$ 192			$ 192
	$ 92,797	**$ 100,337**	**$ 165,432**	**$ 114,162**	**$ 162,565**	**$ 94,137**	**$ 729,430**

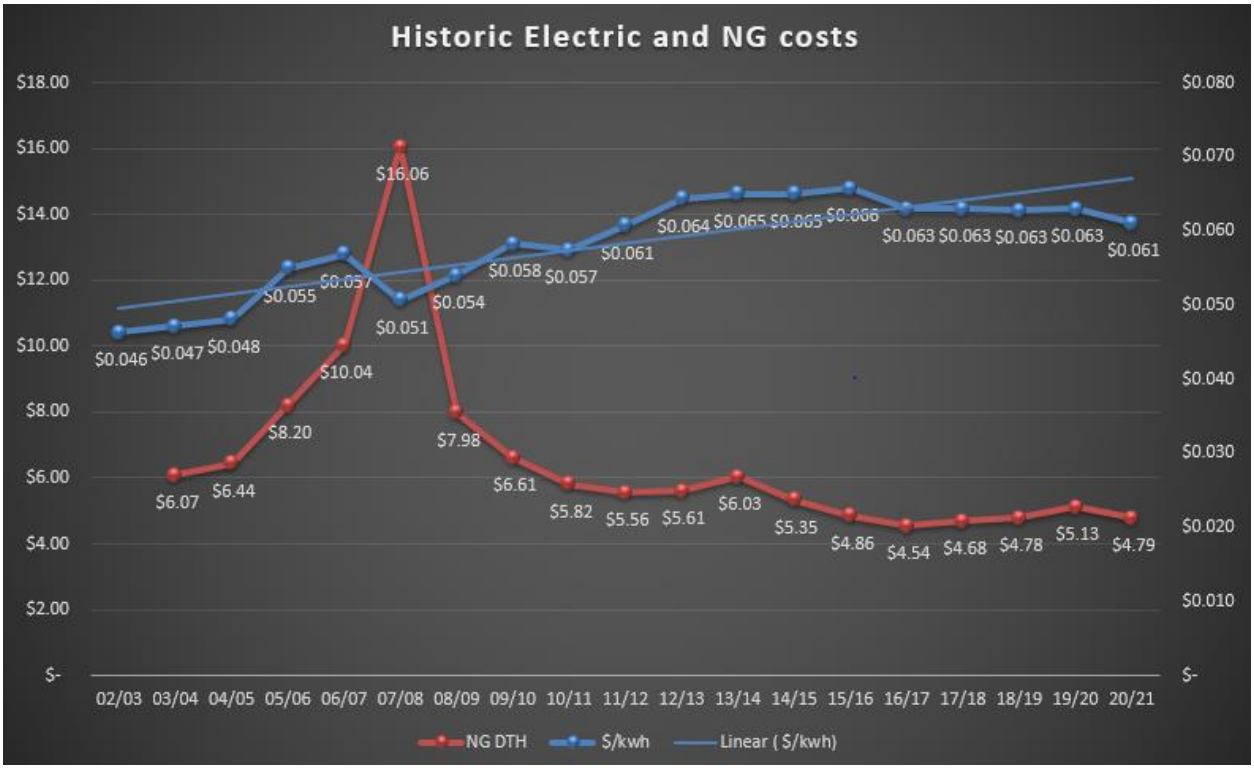
Recovered steam plant operational costs to date from campus wide meter upgrade



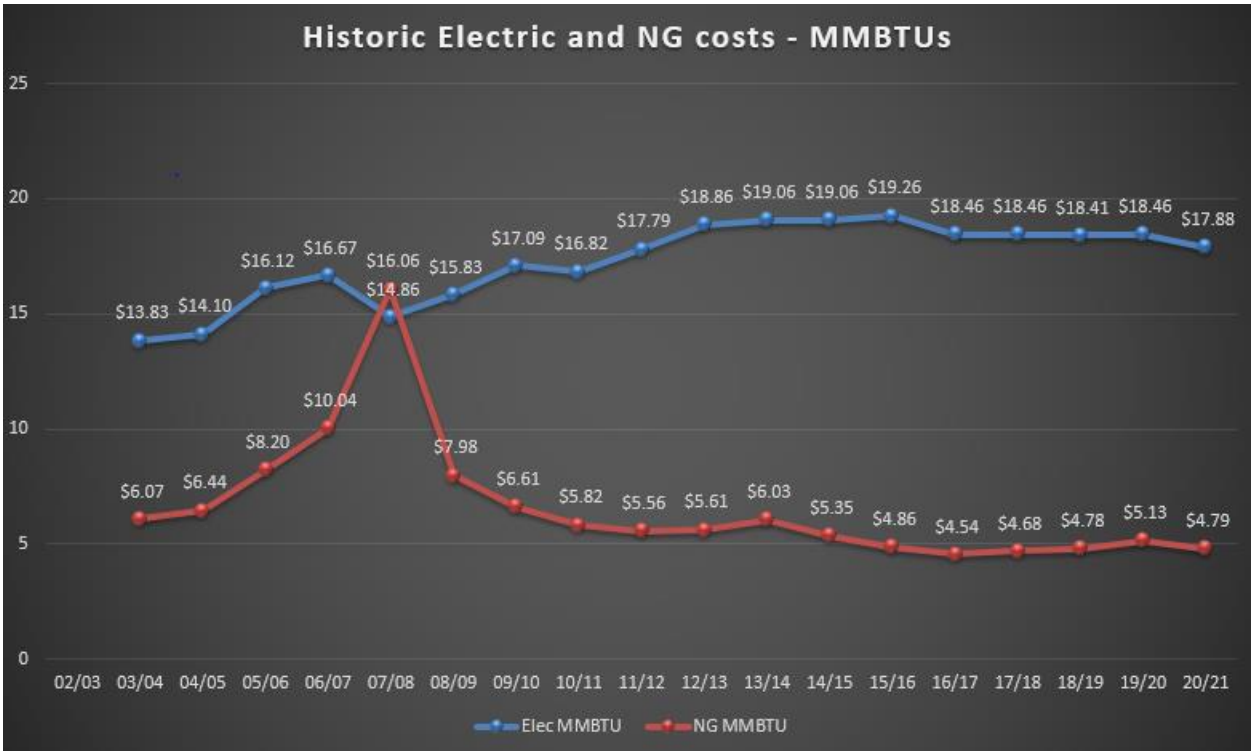
EUI and student growth compared to baseline FY 2002/2003; One BTU is equal to the energy in one match, WCU used the equivalent of 89,686 matches per square foot in F20/21.



More importantly total energy usage (MMBTUs = million BTUs) has also dropped over the last five years despite a 74% increase in students and 37% growth in campus square footage compared to baseline year of 2002/2003.



Electric cost per kWh and Natural Gas cost per Dekatherm (DTH)



Cost comparison for equal amount of energy (1,000,000 BTUs) ; electric almost 4x the cost to provide same amount of heat ; useful information for when projects want to use electric heating which typically has a lower initial cost

Building	Januar	Februar	March	Apri	May	June	Total	% of Total metered
Hunter Library	833,766	813,559	787,296	785,294	318,129	0	6,884,603	12.8%
Stillwell	915,140	748,482	656,133	545,036	254,320	0	6,577,708	12.2%
Coulter	391,897	381,889	427,183	372,556	144,074	0	3,805,742	7.1%
NSB	570,481	417,100	304,402	190,661	137,310	67	3,365,067	6.2%
FPAC	25,273	-41,850	0	0	0	0	3,198,978	5.9%
Belk	301,641	482,010	582,132	455,673	189,382	17,500	3,161,311	5.9%
Reynolds Hall	310,415	307,563	311,132	102,807	29,449	48,622	2,123,097	3.9%
Buchanan	279,238	268,593	252,191	139,536	36,385	39,976	2,087,690	3.9%
McKee Building	296,340	269,892	183,652	191,432	72,263	8,505	1,990,187	3.7%
Campus Rec Center	245,154	187,934	118,720	102,290	57,988	14,762	1,965,396	3.6%
Benton	172,438	306,670	305,794	155,316	26,313	0	1,907,708	3.5%
Balsam Residence	237,265	195,390	253,736	260,625	87,261	0	1,697,657	3.1%
Brown	274,319	240,042	248,607	124,248	76,704	86,903	1,623,648	3.0%
Central Drive	58,668	111,823	250,200	238,991	97,547	42,965	1,470,576	2.7%
Madison Hall	174,790	159,452	146,784	113,324	47,872	59,047	1,461,201	2.7%
Courtyard Dining	0	0	0	0	0	0	1,450,318	2.7%
Albright	174,239	193,588	179,418	110,313	23,102	0	1,306,244	2.4%
Blue Ridge Residence	160,211	129,529	167,375	159,928	45,169	0	1,214,746	2.3%
Forsyth Building	-276,796	196,023	138,669	116,468	40,666	0	1,066,061	2.0%
Old Student Union	98,495	108,670	87,153	89,655	67,387	59,965	1,054,009	2.0%
Killian	121,530	100,247	68,563	118,178	0	0	1,041,591	1.9%
HF Robinson Building	118,269	100,710	0	0	0	0	840,414	1.6%
Killian Annex	140,254	118,378	76,861	69,239	24,053	2,535	828,546	1.5%
Bird	104,067	93,546	76,661	55,503	19,909	0	683,618	1.3%
UC Hinds	0	33	129,770	128,303	33,927	3,153	653,789	1.2%
Robertson Hall	161,829	0	0	0	0	0	380,538	0.7%
CAT	21,444	19,253	12,662	3,140	1,213	0	113,471	0.2%
Reid Gym	0	0	0	0	0	0		
							53,953,914	

Steam usage (lbs.) for FY20/21; missing or incomplete data in red

In FY20/21, we measured 53,953,914 lbs. of steam at the building condensate meters compared to 81,594,488 lbs. produced at the steam plant. Considering that the steam charts at the plant over-estimate production and the building condensate meters won't capture what's flashed off or diverted down the drain when a condensate leak is identified, this represents 66.1% of production (lbs. at condensate meters / steam charts at plant)

If you use the steam plant production data, it results in a plant efficiency of 65% (BTUs in lbs. of steam produced / BTUs in natural gas consumed). Based on the steam condensate meters at the buildings you have a plant and system efficiency of 43% (BTUs based on gallons of steam condensate measured at building level / BTUs in natural gas consumed). Both numbers are down from the past year (75% to 65% at the steam plant and 56% to 43% at the building meters) due to condensate leaks that prevent heated water from returning to the steam plant.

The steam readings above in red represent either incomplete data or a condensate leak which shows zero as the steam condensate goes to the drain before the meter instead of continuing to leak under campus.

Row Labels	Sum of Steam	Steam cost	Sum of kWh	Electric Cost
Belk	5,745,847	$ 89,286	2,337,115	$ 147,939
Bird Building - Health Services	671,565	$ 10,958	272,174	$ 17,113
CAT	113,471	$ 1,796	402,559	$ 24,771
Forsyth Building	1,081,973	$ 16,145	1,130,274	$ 70,965
FPAC	7,018,445	$ 106,842	1,819,860	$ 112,597
HF Robinson Building	2,285,877	$ 34,976	648,900	$ 40,282
Killian	1,111,714	$ 17,054	664,900	$ 41,983
Killian Annex	893,631	$ 13,825	195,060	$ 11,965
McKee Building	2,145,950	$ 33,539	397,615	$ 24,535
Old Student Union		$ -	35,580	$ 2,227
Grand Total	**21,068,472**	**$ 324,421**	**5,568,722**	**$ 346,548**

1.559	lbs CO_2 / kWh
11.71	lbs CO_2 / CCF or 1 therm
22.4	lbs CO_2 / gallon of #2 oil
26	lbs CO_2 / gallon of #6 oil
12.7	lbs CO_2 / gallon of propane

Belk estimate based on 70% of $211,342, last total electric usage

Weekend setback 2 day (28% reduction and $0.033 per kWh weekends)

Building	Sum of Steam	Steam cost	Sum of kWh	Electric Cost	Lbs. of CO2 - steam	Lbs. of CO2 - electric
						CO_2 reduction
Belk	1,641,671	25,510	667,747	22,036	381,596	1,041,018
Bird Building - Health Services	191,876	3,131	77,764	2,566	44,600	121,234
CAT	32,420	513	115,017	3,796	7,536	179,311
Forsyth Building	309,135	4,613	322,935	10,657	71,856	503,456
FPAC	2,005,270	30,526	519,960	17,159	466,112	810,618
HF Robinson Building	653,108	9,993	185,400	6,118	151,811	289,039
Killian	317,632	4,873	189,971	6,269	73,832	296,165
Killian Annex	255,323	3,950	55,731	1,839	59,348	86,885
McKee Building	613,128	9,582	113,604	3,749	142,518	177,109
Old Student Union	0	0	10,166	335	0	15,848
Grand Total	**6,019,563**	**$ 92,692**	**2,258,296**	**$ 74,524**	**1,399,208**	**3,520,684**
		$ 167,216	**Annual Savings**		**4,919,892**	**lbs. steam & electric**

Calculation of CO_2 savings with weekend setback for 10 office and academic buildings. Savings and reduction calcuations are rough estimates to demostrate potential savings and should not be taken as exact