Western Carolina University

Updated Strategic Energy Plan

With Usage for FY 2016-2017

Submitted September 6th, 2017

Office of Sustainability & Energy Management

Facilities Management

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

Executive Summary

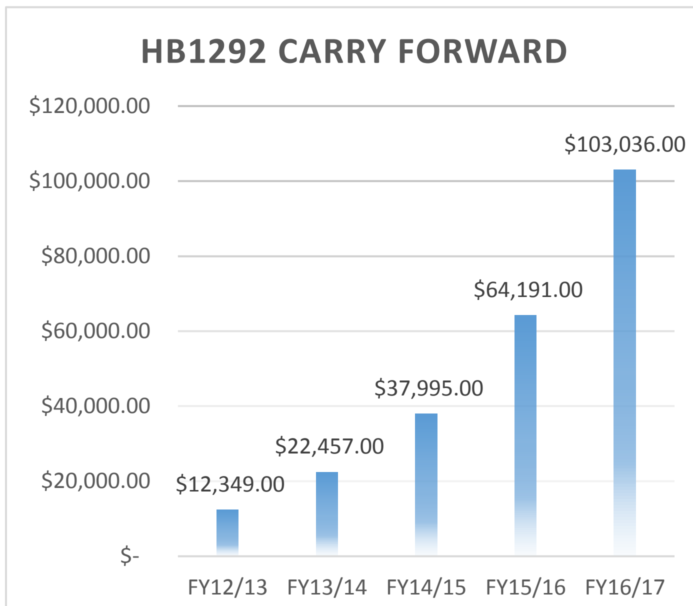
Approach

WCU's approach to Energy Management continues to focus 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 also central to energy management at WCU. The on-going upgrade to ultra-sonic steam condensate meters has not only brought to light previously unaccounted steam usage, but has improved benchmarking efforts. By comparing WCU's building energy usage to building stock of similar end use we can identify buildings that are underperforming and are potential candidates for conservation and efficiency efforts.

Summary of Fiscal Year 16/17:

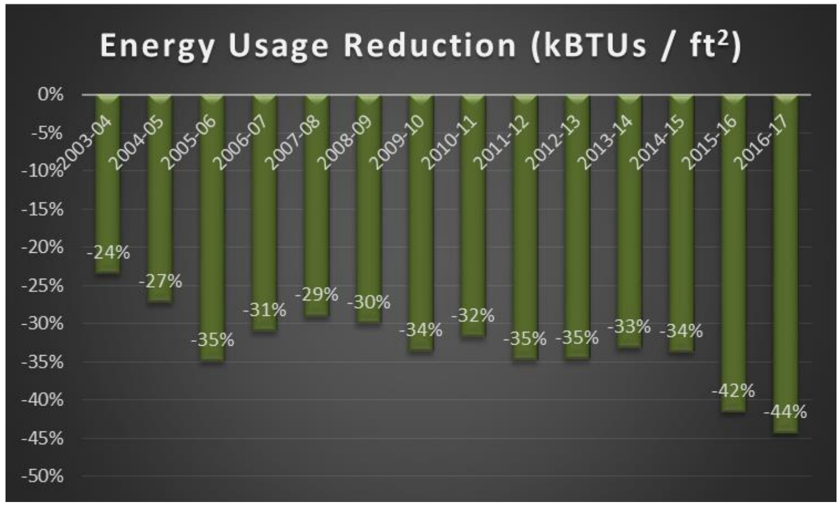
- WCU currently stands at a **44% reduction** in energy usage intensity (EUI) compared to the baseline year of 2002-2003. **This exceeds the State Energy Office's Utility Savings Initiative of 40% by 2025.**
- HB 1292 Carry Forward which documents energy saving projects has grown **from $12,349 in FY12/13 to $103,036 in FY16/17 ($227,679 to date)**
- **Recovered steam revenue in FY16/17 was $91,294 ($188,581 over the past two years since upgrading to ultra-sonic).**
- Steam meter upgrades to ultra-sonic have revealed that half of the top ten steam users on campus were previously unmetered; state appropriated buildings currently account for **$350,172 in previously unmetered steam usage**.



- Re-tuning efforts at the Health and Human Science Building have **reduced electrical usage by almost 400,000 kWh (with an ROI of approximately 95%)**; to date electrical costs at HHS have **been reduced by $45,418 from $238,526 in the first year of operation to $193,108** for the past fiscal year.
- **Total Utilities for FY16/17 - $3,991,780 (Electric - $2,762,870, NG - $764,069, Water - $409,052)**

This document summarizes the past fiscal year's usage along with an update on past goals and future direction which is evolving based on feedback from current projects and increasing meter data.

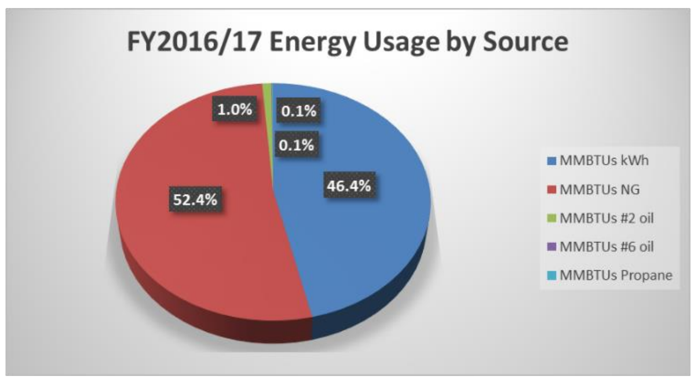
FY16/17 Usage



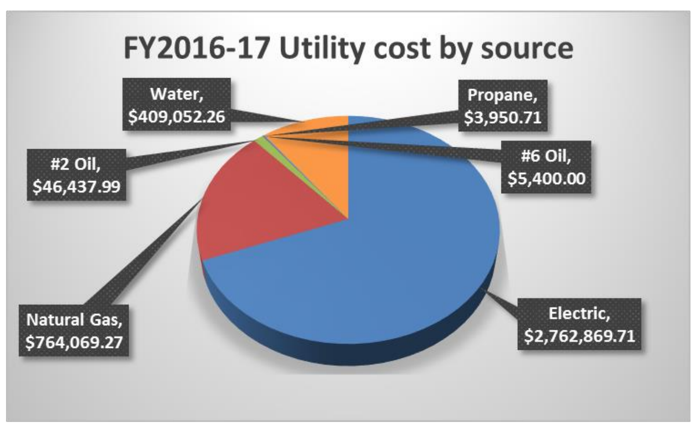
WCU currently stands at a 44% reduction in energy usage intensity (EUI) compared to the baseline year of 2002-2003. This exceeds the State Energy Office's Utility Savings Initiative of 40% by 2025.

In addition to reduced usage, lower electric rates and natural gas prices reduced total utility costs from $4.1 million in the previous fiscal year to just under $4.0 million for FY16/17 (Appendix Figure 1 – Historic Utility Costs and Usage). The blended rate for electricity (all electric costs divided by kWh) went from $0.0657/kWh to $0.0635/kWh. Natural gas rates also continued to decrease from $4.86 to $4.54 per Dekatherm (DTH) (Appendix Figure 2 – Historic Electric and NG Costs).

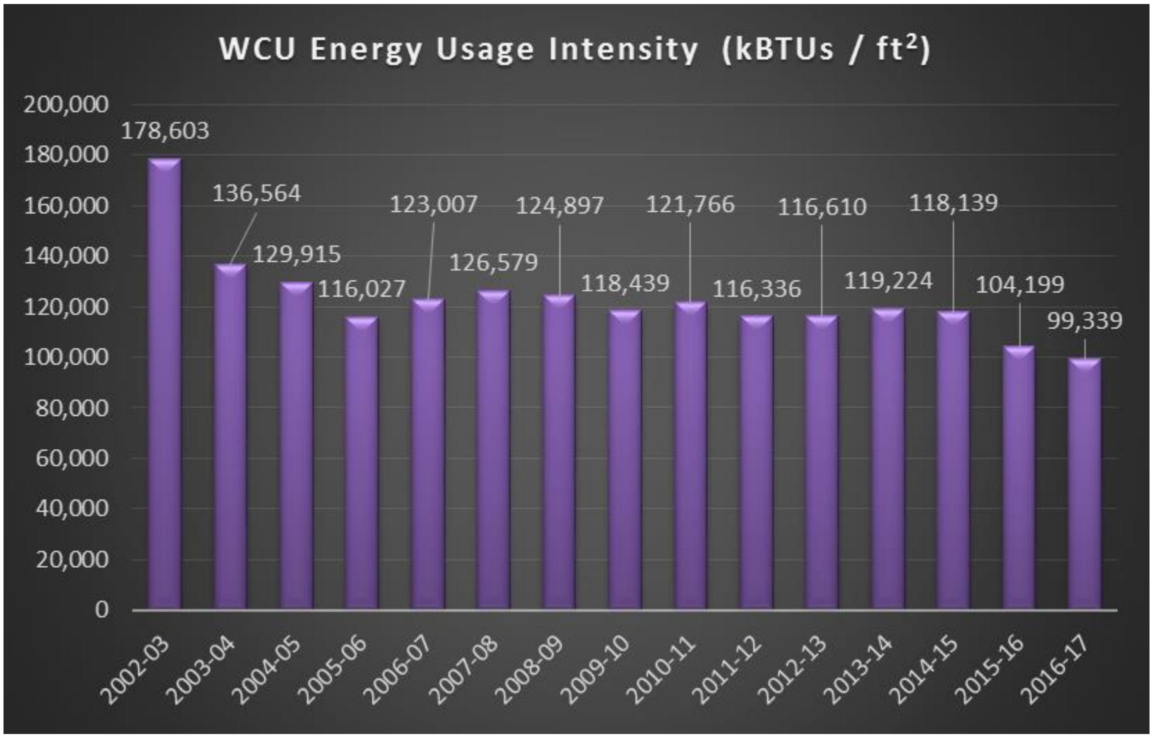
While natural gas accounts for 52.4% of total energy usage compared to 46.4% for electricity, total electricity costs are 3.6 times that of total natural gas costs ($2,762,869 compared to $764,069). Focus on reducing electrical usage may have slightly less impact on energy usage compared to reducing natural gas usage, but is more cost effective.



Total water cost and usage was up in FY16/17, $409,052 compared to $353,745 the previous fiscal year. Part of this can be attributed to the addition of Noble Hall, but does not explain all of the increase in usage from 97.9 million gallons to 105.4 million gallons.



Early in the fiscal year, due to drought conditions, water levels on the Tucaseegee were extremely low which impacts the water intake for WCU's water treatment plant. This prompted an examination of buildings with high water usage which confirmed an issue identified by the HVAC shop with a walk-in refrigeration cooler at Hinds University Center. Repair to that refrigeration unit saved over 1.3 million gallons and is on pace to save the University Center approximately $10,000/yr.



The past fiscal year saw WCU's energy consumption decrease to under 100 kBTUs / ft2 for the first time since the baseline year of 2002-2003. For perspective one BTU (British Thermal Unit) is equal to the amount of energy in one match (WCU's current energy usage intensity represents the equivalent of 100,000 matches for every square foot on campus).

Fiscal Year	Total Utilities	Gross Square Footage	Total Utility Cost per Gross ft2	Total MMBTUs	$ / MMBTU	% change MMBTU	kBTU/ft2	% change kBTU/ft2
2002-03	$3,075,813	2,355,330	$1.31	420,668	$6.36	0	178,603	0
2003-04	$3,300,828	2,355,330	$1.40	321,653	$9.19	-24%	136,564	-24%
2004-05	$3,798,840	2,734,121	$1.39	355,204	$9.60	-16%	129,915	-27%
2005-06	$4,385,079	2,734,121	$1.60	317,233	$12.81	-25%	116,027	-35%
2006-07	$4,404,131	2,843,308	$1.55	349,747	$11.66	-17%	123,007	-31%
2007-08	$4,878,278	2,790,749	$1.75	353,251	$12.90	-16%	126,579	-29%
2008-09	$4,388,322	2,863,949	$1.53	357,698	$11.36	-15%	124,897	-30%
2009-10	$4,187,337	2,798,946	$1.50	331,504	$11.71	-21%	118,439	-34%
2010-11	$4,175,587	2,911,228	$1.43	354,487	$10.92	-16%	121,766	-32%
2011-12	$4,293,145	2,954,814	$1.45	343,751	$11.51	-18%	116,336	-35%
2012-13	$4,572,035	3,105,538	$1.47	362,137	$11.78	-14%	116,610	-35%
2013-14	$4,912,535	3,103,210	$1.58	369,976	$12.39	-12%	119,224	-33%
2014-15	$4,682,160	3,103,210	$1.51	366,611	$11.77	-13%	118,139	-34%
2015-16	$4,099,823	3,103,210	$1.32	323,352	$11.59	-23%	104,199	-42%
2016-17	$3,991,780	3,223,781	$1.24	320,246	$11.19	-24%	99,339	-44%

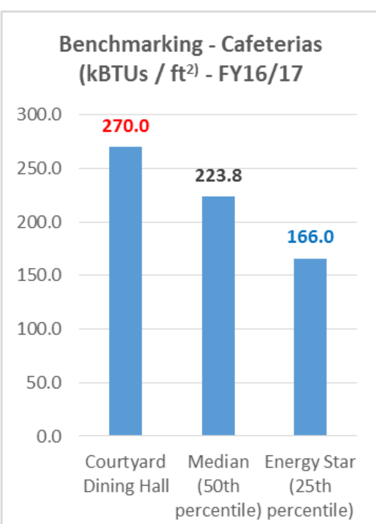
Despite adding over 900,000 ft^2 in the past 13 years, WCU has a total energy usage similar to that of FY2003-2004 (1 MMBTU = 1,000,000 BTUs).

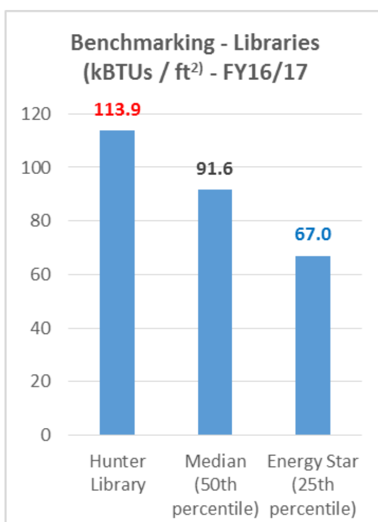
Strategic Energy Plan

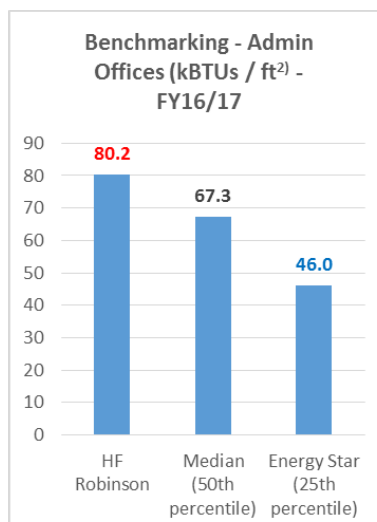
As mentioned in the summary, WCU's approach to Energy Management is to focus on demand-side management by implementing no-cost to low-cost proven conservation and energy efficiency measures first. This is typically accomplished via the existing BAS software which operate the heating, ventilation, and air conditioning (HVAC) systems for 2.2 million square feet of the 3.2 million square feet on campus. Given that HVAC systems typically represent 40-50% of a building's total energy usage, this is the biggest slice of the energy pie and the most cost effective target to control.

A past example would be the air handler serving the Theatre at the Fine and Performing Arts Center which had a failed temperature sensor which was causing it to run 24/7. Discussion with the building manager also revealed that the air handler was only needed for events and did not create comfort issues when turned off. This resulted in an avoided electrical cost of $12,639/yr. and an energy savings of 191,515 kWh/yr. Harder to quantify is the additional benefit of reduced maintenance and the extended life of the mechanical equipment.

"You can't manage what you don't measure." While this is an old business adage, it is also central to energy management at WCU. With over 200 electric, steam, and water meters across campus, continued data collection and evaluation is essential to identify anomalies and to assess the effectiveness or ineffectiveness of efficiency projects. The on-going upgrade to ultra-sonic steam condensate meters has not only brought to light previously unaccounted steam usage, but has improved benchmarking efforts. By comparing WCU's building energy usage to building stock of similar end use we can identify buildings that are underperforming and are potential candidates for conservation and efficiency efforts. This has also proved to be valuable information when assessing the validity of energy modeling targets for new buildings (i.e. STEM and Upper Campus Residential Hall). Three candidates for further examination below.





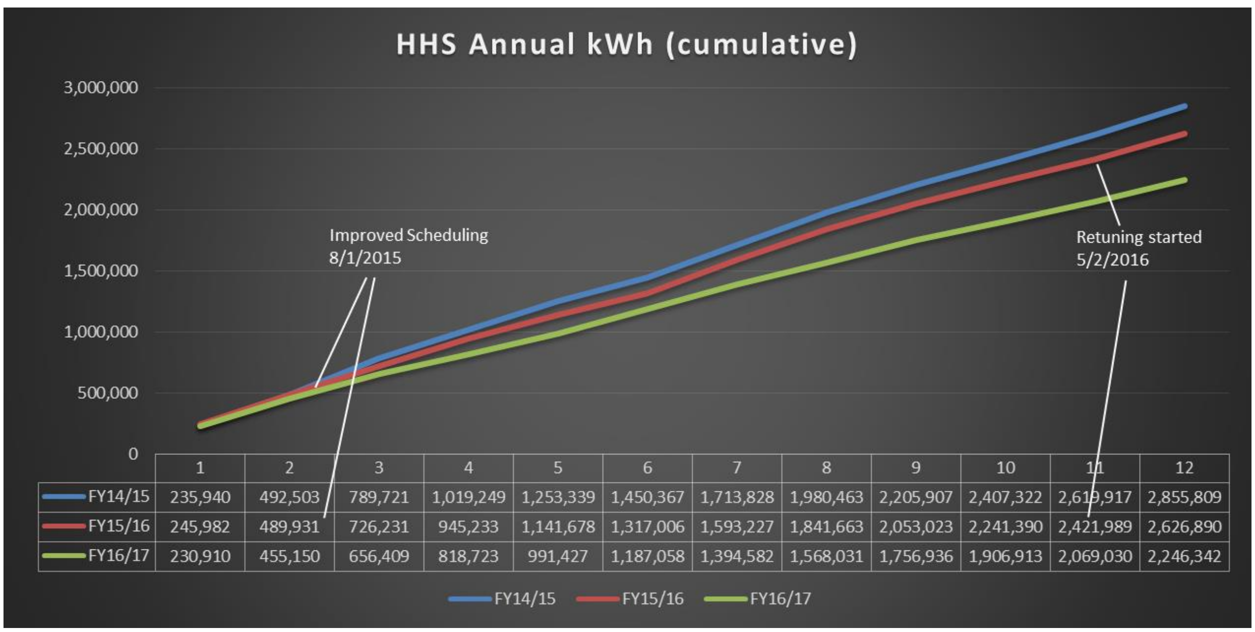


Future Focus

Over the past four years energy management efforts have documented over $227,679 in avoided energy costs ($116,300 attributed to repairs by the HVAC and Plumbing shop to steam condensate system). In addition, $188,581 has been recovered in lost steam revenue over the past two years with the upgrade to ultra-sonic meters. While only seven steam condensate meters remain to be upgraded, the Re-tuning project at HHS has shown potential for future projects across campus.

According to the Pacific Northwest National Laboratory, 10-30% of the energy used in commercial buildings is wasted due to improper and inefficient operations (PNNL, 2017). Re-tuning involves the re-calibration (i.e. temperature, humidity, CO2 sensors) and optimization of existing equipment typically via the programming logic in the BAS software. The BAS is also used to trend mechanic equipment to assess performance pre and post assessment (i.e. how close the discharge temperature is to setpoint). In short, it is an optimization of existing equipment without major capital upgrades or lengthy commissioning reports.

Re-tuning efforts at HHS have reduced electrical usage by 15%, almost 400,000 kWh. To date electrical costs at HHS have been reduced by $45,418 from $238,526 in its first year of operation to $193,108 for the past fiscal year. The Re-tuning project had an ROI of approximately 95%, the S&P 500's highest 15 year performance had a compound return of 18.3% from 1985 through 1999 (Marketwatch, 2015).



	1	2	3	4	5	6	7	8	9	10	11	12
FY14/15	235,940	492,503	789,721	1,019,249	1,253,339	1,450,367	1,713,828	1,980,463	2,205,907	2,407,322	2,619,917	2,855,809
FY15/16	245,982	489,931	726,231	945,233	1,141,678	1,317,006	1,593,227	1,841,663	2,053,023	2,241,390	2,421,989	2,626,890
FY16/17	230,910	455,150	656,409	818,723	991,427	1,187,058	1,394,582	1,568,031	1,756,936	1,906,913	2,069,030	2,246,342

While an outside engineering consultant was hired for the project, similar projects could be performed in-house with minimal additional training.

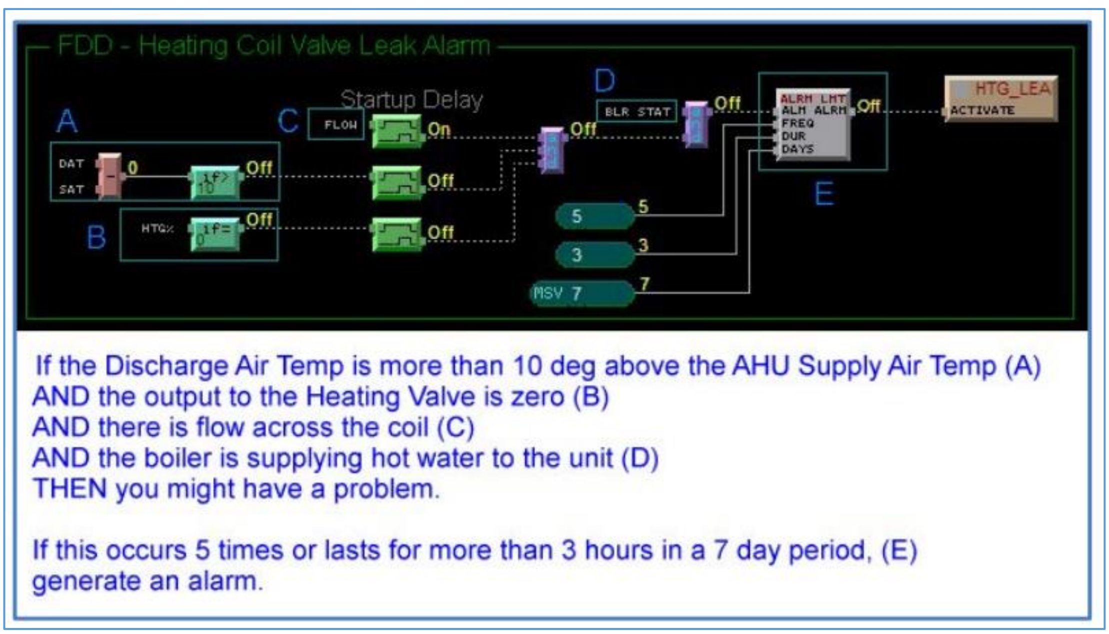
However, Energy Management is currently a staff of one responsible for: 2.2 million square feet of BAS systems, resolving daily comfort issues related to BAS equipment, management and evaluation of 200 plus meters, analyzing monthly usage for campus billing, review of monthly steam plant report, in addition to the review and implementation of BAS systems on new capital projects and renovations (i.e. STEM and Brown renovation).

The addition of a BAS controls technician to address daily comfort issues would enable Energy Management to effectively address current goals and to create a team of two necessary to implement re-tuning projects (HHS is currently the only energy related project underway). Considering that commissioning of new capital projects has only been required in recent years, the majority of buildings on campus have never undergone an extensive third party review of their mechanical and BAS systems (commissioning still does not guarantee energy savings considering that HHS was commissioned and most of the issues uncovered were not part of the commissioning process).

Commissioning at the most basic level can be a one-time checklist to confirm the operation of equipment during the first year of operation. Instead of a reactive approach, a few universities in the UNC system have a proactive re-tuning team (sometimes referred to as retro-commissioning) to address mechanical and BAS systems and associated sensors as they age and drift out of calibration over time.

With the current workload and involvement in the STEM design, no new projects will be started until existing projects have been completed (see next page). Involvement in the STEM design is important considering the complexity of the laboratory fume hood ventilation system, proper integration to the BAS software, and energy intensity of laboratory buildings. A typically laboratory fume hood can use 3-3.5 times as much energy as a home (*Lawrence Berkley Laboratories, 2017*).

Part of the scope for the STEM building is to develop Fault Detection and Diagnostic (FDD) which would further enable the identification of excessive mechanical use and energy waste, preventable issues that may not appear evident until failure or comfort issues arise (example of BAS logic below to identify a leaking hot water valve). Development of this programming logic could be applied to other buildings on campus.



Courtesy of Automated Logic

Update on Energy Management Goals for FY 16/17

- Complete Re-tuning project underway at the Health and Human Science Building (remaining optimization of economizers on air handlers and building pressurization issues to address).

  Status – Re-tuning project has reduced usage by 15% and saved almost 400,000 kWh in the 12 months since the project started with a cost avoidance of $31,400 (using historical resale rate of $0.079). This represents approximately a 95% return on investment with a simple payback of just over one year (the S&P 500's highest 15-year performance had a compound return of 18.3% from 1985 through 1999). Since the building came on-line in 2012, electric utilities have been reduced by $45,417 (from $238,525 in FY12/13 to $193,108 in FY16/17).

- Install Events2HVAC at the Health and Human Science Building which will reduce unnecessary run hours by applying schedule entered in 25Live to schedule controlled by building automation system.

  Status – on hold until HHS Re-tuning completed

- Develop a migration plan for building automation systems that have hardware components that are no longer manufactured.

  Status – Buildings have been identified, plan is to upgrade at least one building in the coming fiscal year which would also provide available parts for other buildings until they can be upgraded.

- Complete upgrade of remaining 12 steam condensate meters to ultrasonic meters and where feasible begin integration with building automation system in order to see real time usage.

  Status – Currently lack steam meters on 7 buildings (Bird, Coulter, Madison, Old Student Union, Robertson, Breese, and Reid). Upgrade has brought to light $350, 172 in previously unmetered steam usage for state appropriated buildings. Five of the ten buildings with highest steam consumption were previously unmetered. Recovered steam revenue in FY16/17 was $91,294 ($188,581 over the past two years.)

- Attend University of Wisconsin course on optimization of building automation systems

  Status – on hold

- Finish building automation system upgrade at Hinds University Center and implement optimal control sequences (lessons learned) from HHS re-tuning project.

  Status – Upgrade completed. Cooling demand from Coulter is still a major driver of energy usage for the chiller at Hinds.

- Organize a hands-on test, adjustment, and balance training (TAB) that will provide training opportunities for HVAC staff while performing necessary TAB work at Hinds University Center.

  Status – Training completed, TAB performed in-house after training workshop for HVAC shop. TAB work at the UC uncovered multiple areas with insufficient airflow.

- Create a building controls specification to ensure that the university is getting a capable building automation system that increases ability to troubleshoot mechanical issues, identify energy saving opportunities, schedule at a zone level, robust trending ability, etc.

  Status – Specification created for STEM building; additional development of Fault Detection and Diagnostics (FDD) also underway for STEM project. Goal of FDD is to identify excessive mechanical use and energy waste before equipment failure or comfort issues arise (i.e. use of chilled water to compensate unwanted heat from leaking hot water valve).

- Integrate solar generation at the Solar Lounge / EGG with Ecoscreen in order to make real-time solar data accessible for students and class projects.

  Status - Pending

- Along with relevant staff, complete Exposure Control Technologies training on Laboratory Ventilation in September which will better prepare staff for planned STEM building.

  Status – Completed training with WCU EHS staff. Many of the principles learned have been included in design for STEM building.

- Address suspect electric meters and incorrect multipliers at Ramsey, Camp Lab, Stillwell, Breese, Hoey, McKee, and Old Student Union. Add electric meter to Facilities, Camp Gym, Camp Police Station. Need to standardize on a good electric meter with display that can easily be integrated with BAS.

  Status – On-going, meter factor corrected at Stillwell, new meters ordered by Electric Shop for Breese, Hoey, Mckee, and Belk.

- Address Chilled Water Reset at chiller plants across campus. Many of the chiller plants can adjust their chilled water temperature based on outside air temperature (OAT). However, it has been observed that while the program in the building automation system changes the set point as the OAT changes, the chillers are still putting out the same low temperature chilled water (42°F water at 55°F or 85°F OAT regardless).

  Status - Chiller optimization is a focus of future efforts. Costs associated with electric demand are the highest in the summer with the peak in September coinciding with afternoon cooling demand.

- Replace 1950's era #2 fuel oil boiler at Facilities (11th most expensive building on campus per ft^2) with high efficiency natural gas condensing unit.

  Status – quote obtained to move forward, approval pending

- Develop a CO_2 calculator to determine energy related emissions

  Status – pending

Appendix

Fiscal Year	Total Utilities	Gross Square Footage	Total Utility Cost per Gross ft2	Total MMBTUs	$ / MMBTU	% change MMBTU	kBTU/ft2	% change kBTU/ft2
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2016-17	$3,991,780	3,223,781	$1.24	320,246	$11.19	-24%	99,339	-44%

Figure 1 – Historic Utility Costs and Usage

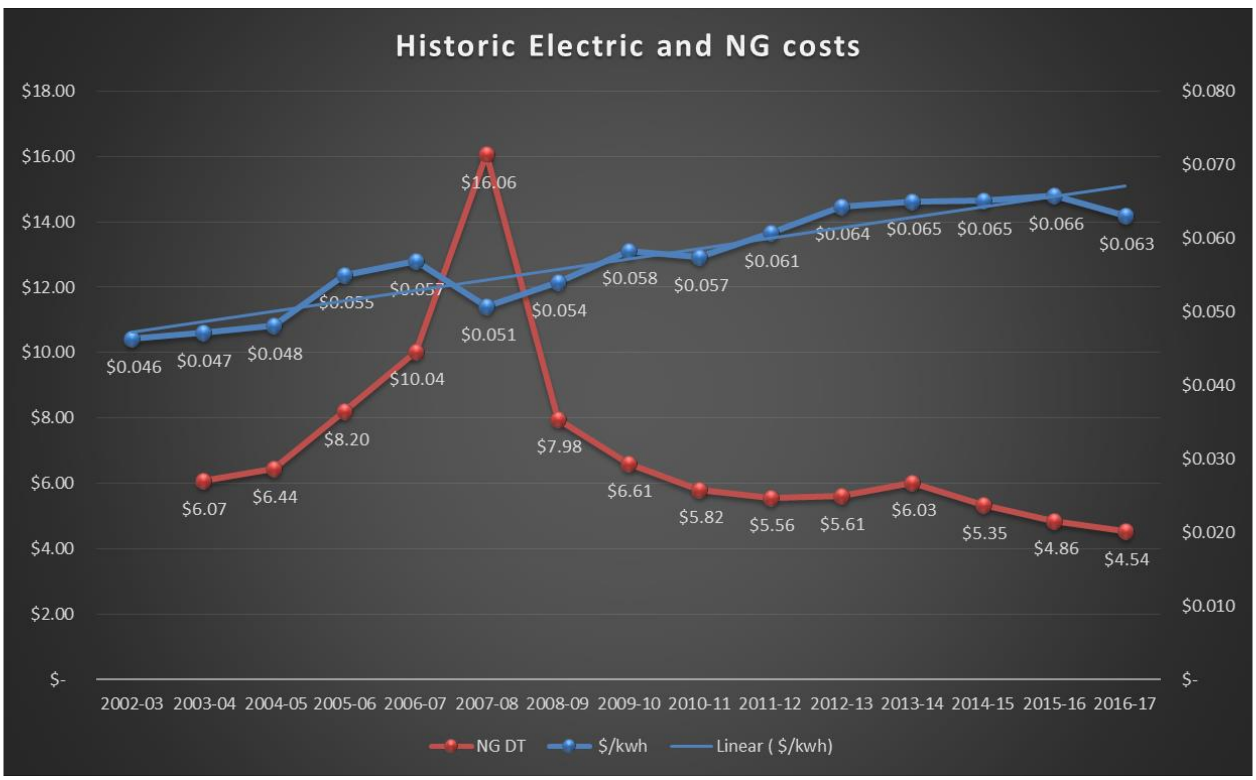

Figure 2 – Historic Electric and NG Costs

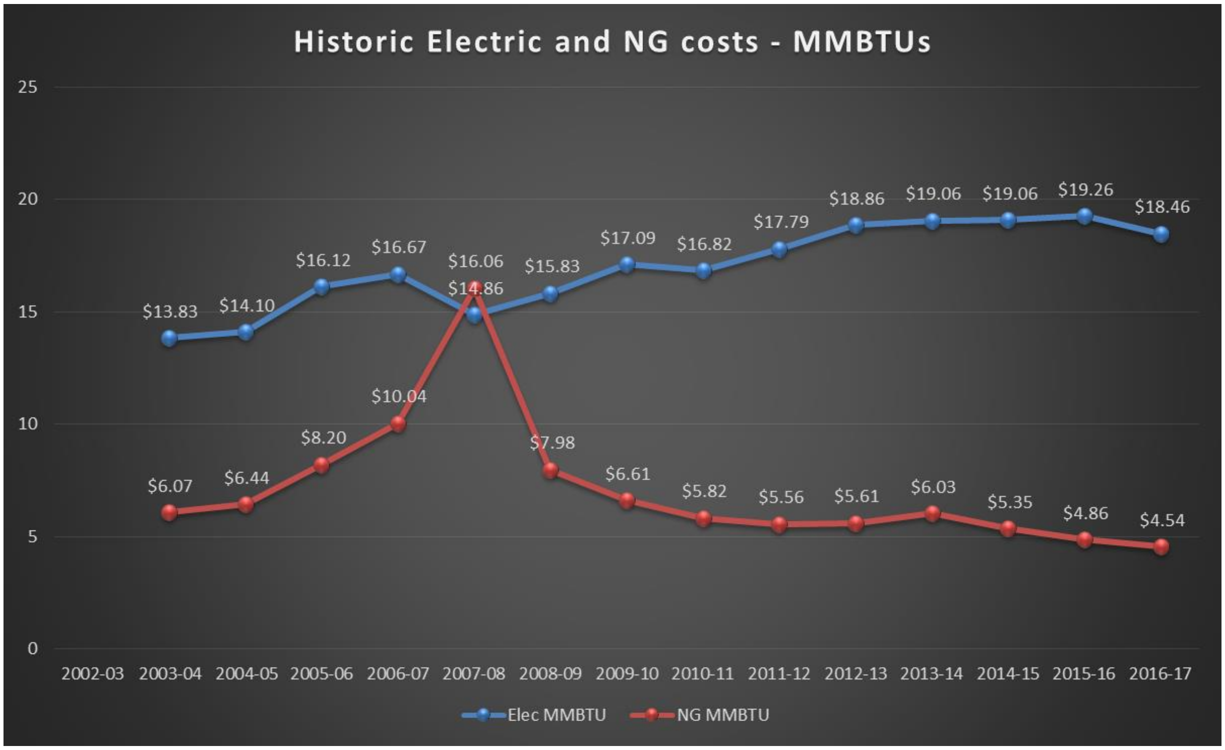

Figure 3 – Comparison by MMBTU for Historic Electric and NG Costs

	Top 10 Cost by Electric (FY16/17)		
1	Ramsey Center *(FY15/16)*	**$**	**220,532.60**
2	Health and Human Science	$	193,108.42
3	Hunter Library	$	171,725.45
4	Courtyard Dining	$	134,380.10
5	FPAC	$	114,705.11
6	Natural Science Building	$	104,689.07
7	Hinds University Center	$	101,647.62
8	Coulter Building	$	81,295.11
9	Forsyth Building	$	77,426.88
10	Stillwell Science Building	$	76,905.77

	Top 10 Cost by Steam (FY16/17)		
1	Hunter Library	**$**	**93,798.46**
2	Scott Hall	$	84,182.40
3	Courtyard Dining	$	74,468.63
4	FPAC	$	62,460.52
5	Natural Science Building	$	61,534.02
6	Albright-Benton Residence Hall	$	47,547.64
7	Walker Residence Hall	$	47,087.50
8	HF Robinson Administration Building	$	34,549.98
9	Stillwell Science Building	$	32,073.63
10	Central Drive Residence Hall	$	30,391.97

	Top 10 Cost by Water (FY16/17)		
1	Scott Hall	**$**	**25,243.46**
2	Courtyard Dining	$	23,371.34
3	Hinds University Center	$	15,389.89
4	Walker Residence Hall	$	14,889.42
5	Village Residence	$	14,548.46
6	Reynolds Hall	$	12,534.10
7	Steam Plant	$	11,680.96
8	Albright-Benton Residence H	$	9,471.92
9	Balsam Residence Hall	$	8,873.93
10	Blue Ridge Residence Hall	$	7,719.52

	Top 10 Cost by Total utilities / ft2		
1	Courtyard Dining	**$**	**4.36**
2	Water Plant	$	3.04
3	Steam Plant	$	2.62
4	Natural Science Building	$	2.48
5	Hunter Library	$	1.70
6	Hinds University Center	$	1.57
7	Robertson Hall	$	1.56
8	Jordan Phillips Field House	$	1.40
9	Reynolds Hall	$	1.39
10	FPAC	$	1.38

Energy Usage Intensity (EUI)

Western Carolina University

Based on Gross ft2 in BLDGDATA-TO DATE FILE.XLS

	Building	Year buil	*Building ft^2	kBTUs / ft2_201
1	Courtyard Dining Hall	2009	53,250	270.0
2	Natural Science Building	1977	66,896	173.8
3	Water Plant	1966	2,536	169.6
4	Robertson Hall Apartments	1932	23,010	129.1
5	Hunter Library	1953	156,577	113.9
6	Fine & Performing Arts Building	2004	128,465	98.2
7	Facilities Management	1974	9,000	94.5
8	Steam Plant	1930	12,870	94.3
9	Reynolds Residence Hall	1953	46,999	86.6
10	Hinds University Center	1968	85,873	84.1
11	Walker Residence Hall	1972	70,658	84.0
12	Jordan-Phillips Field House & Wh	1974	15,430	83.8
13	Killian Building	1967	52,149	81.8
14	HF Robinson Administration Build	1979	71,948	80.2
15	Albright-Benton Residence Hall	1962	76,720	79.8
16	Scott Residence Hall	1969	142,655	70.5
17	Campus Recreation Center	2008	75,004	64.7
18	Stillwell Science Building	1952	120,117	64.7
19	Forsyth Building	1970	70,464	61.6
20	Killian Annex	1968	26,466	53.7
21	Balsam Residence Hall	2009	118,909	52.6
22	Center for Applied Technology	1997	27,999	52.1
23	Health & Human Science Building	2012	159,767	49.9
24	Coulter Building	1978	80,308	47.4
25	Blue Ridge Residence Hall	2010	115,588	44.9
26	Hoey Auditorium	1939	17,220	43.8
27	Madison Hall	1939	31,611	39.6
28	Central Drive Residence Hall	2004	103,443	36.3
29	Harrill Residence Hall	1971	77,296	36.0
30	Mckee Building	1939	58,102	33.6
31	The Village	2004	81,935	31.1
32	Buchanan Residence Hall	1959	39,147	27.3
33	Bird Building	1960	14,956	26.7
34	Bookstore	1983	22,383	24.6
35	Belk Building	1971	108,824	21.6
36	Cordellia Camp Lab - Main Buildir	1965	76,883	21.5
37	Norton Residence Hall	2005	74,270	21.1

Figure 5 – EUI (not all energy use data available for numbers in gray)

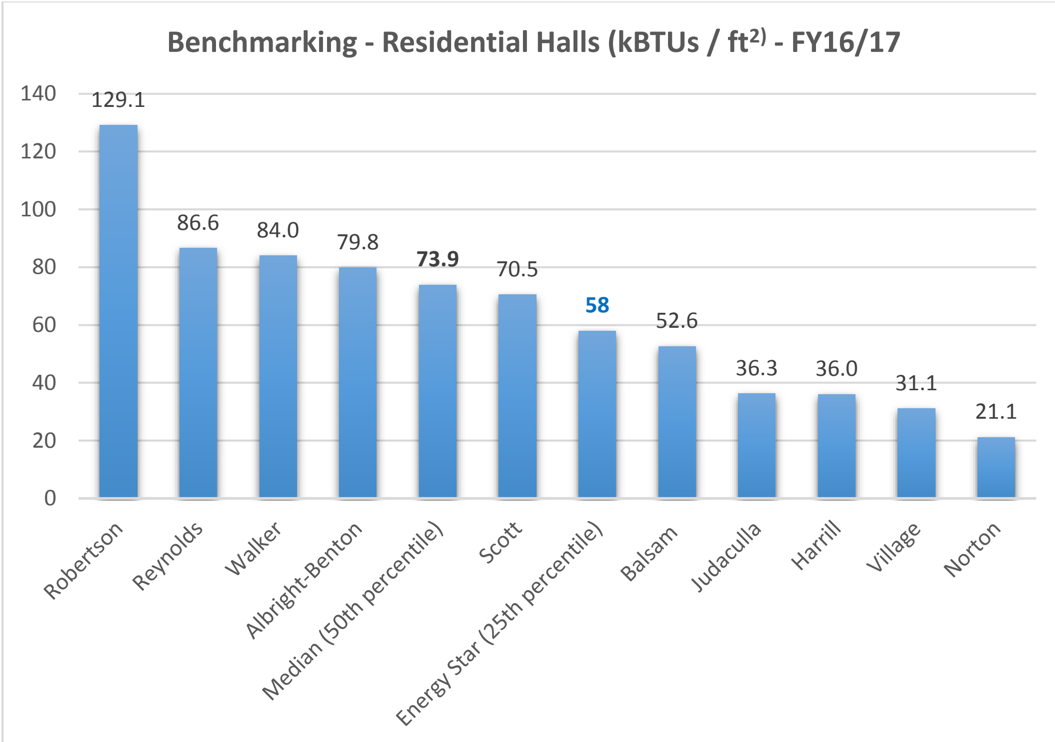

Figure 6 – Benchmarking for Residential Halls (missing steam data for Blue Ridge, chiller plant included for Balsam)

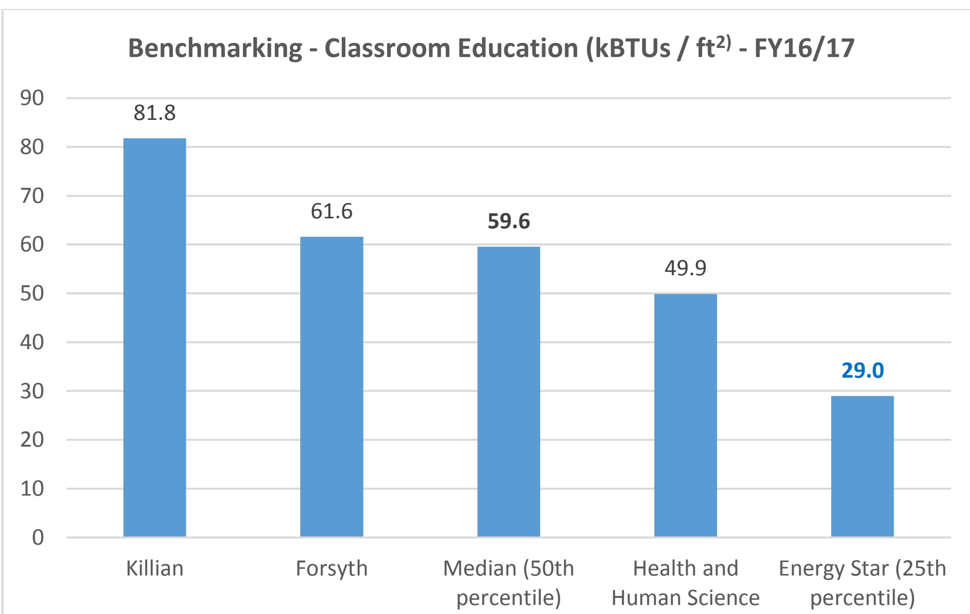

Figure 7 – Benchmarking for Education Buildings (data not available for all buildings)

1292 Carry Forward

Project	Description	FY12/13	FY13/14	FY14/15	FY15/16	FY16/17
HFR renovation	*HVAC / controls upgrade*	$ 12,349.00	$ 12,097.00	$ 13,518.00	$ 12,481.00	$ 12,673.00
Make-up water savings	*Campus wide condensate repairs*		$ 3,482.00	$ 7,783.00	$ 15,118.00	$ 15,893.16
Make-up water savings BTU savings	*Campus wide condensate repairs*		$ 6,878.00	$ 16,694.00	$ 25,806.00	$ 24,645.71
HHS Savings	*Retuning and Scheduling projects*				$ 10,786.00	$ 37,184.14
Fine and Performing Arts	*Scheduling improvement*					$ 12,639.99
		$ 12,349.00	**$ 22,457.00**	**$ 37,995.00**	**$ 64,191.00**	**$ 103,036.00**

Figure 8 – HB 1292 Projects and Savings to Date

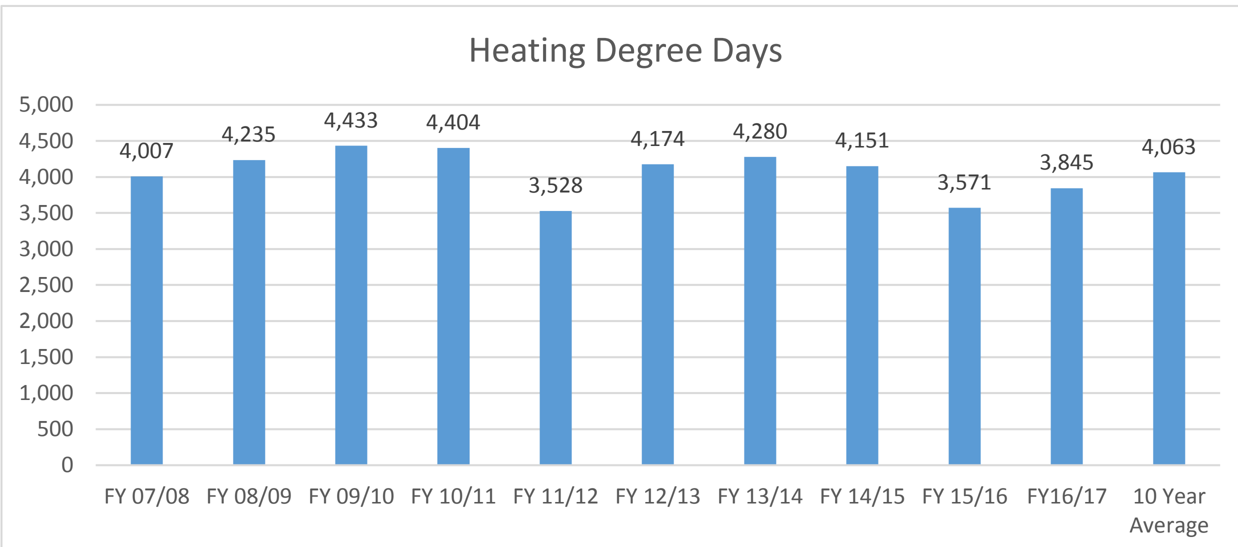

Figure 9– Historic Heating Degree Days

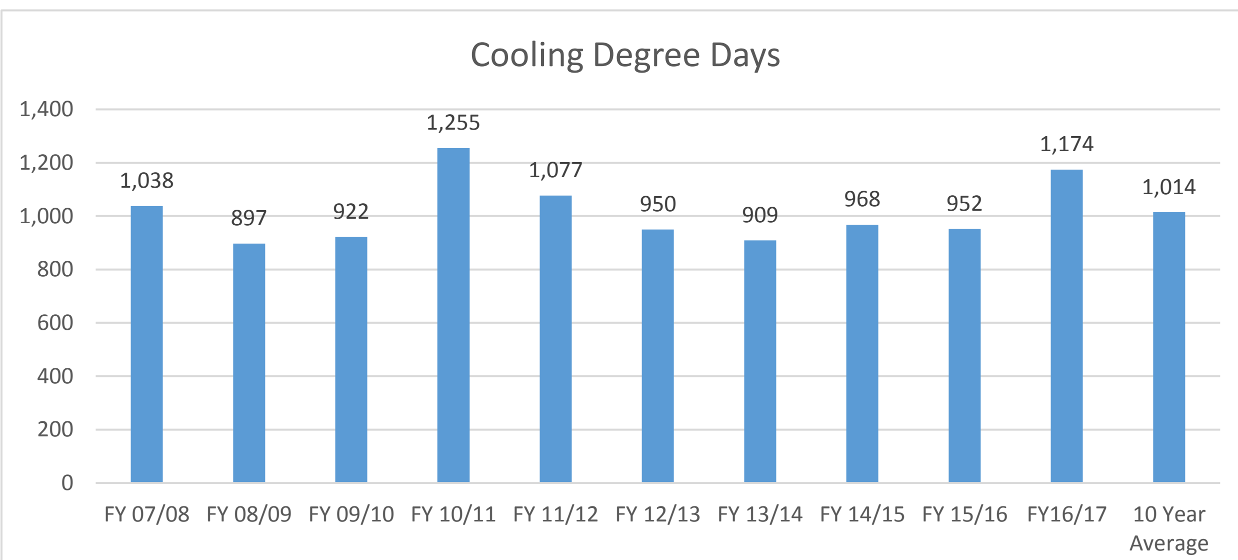

Figure 10– Historic Cooling Degree Days