2018

Energy Management & Utility Usage Report



Mission Statement

The Hamilton County Facility Department is committed to providing strategies, equipment, guidelines and methodologies to achieve tenant comfort in all buildings managed by the Facility Department while aggressively minimizing taxpayer costs and benchmarking the energy efficiency of the facilities managed in the process.

DEPARTMENT OF COUNTY FACILITIES

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HAMILTON COUNTY OHIO

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1 - Executive Summary

Calendar Year 2018 was another successful year for the Hamilton County Facilities Department in regard to managing the electrical, natural gas, and water/sewer cost and usage in the 3.2 million square feet of managed space. We continued the energy-efficient use of our buildings and the best allocation of taxpayer dollars.

- The total cost savings from 2001 through 2018 for our three rate-based Energy Conservation Measures totaled $11,801,832 for facilities managed by the Facilities Department.
  - Electric – in 2018, there was a savings of $92,245 compared to standard Duke Energy rates as a result of bidding out our Electric. Since awarding our first of four contracts in 2010, we have accumulated a total savings of $9,549,943.
  - Natural Gas – in 2018, there was a savings of $89,392 compared to standard Duke Energy rates by being in the CCAOSC Natural Gas Program. Since 2001, we have accumulated a total savings of $1,159,616 being a member of this CCAO program.
  - Interruptible Rate Gas – in 2018, there was a savings of $17,743 by being in the Duke Energy Interruptible Tariff Program at the County Courthouse. Since 2004, we have accumulated a total savings of $729,140 by being a part of this utility program.
- Normalized Energy Usage was typically up in 2018.
  - Electricity usage increased by 11,833,259 kWh from the previous year (7% increase).
  - Natural Gas Usage increased by 39,484 CCF from the previous year (5% increase).
  - Water usage increased by 2,443 CCF from the previous year (a 3% increase).
- In 2018, two more buildings qualified for the U.S. EPA Energy Star Awards. These buildings are in the top 25% most efficiently operated buildings in the United States. Energy Star recently updated the baseline data for all buildings, resulting in an average 12-14 point drop in score for buildings across the United States. If the EPA does not change their revised rating system for 2019 then several buildings that qualified in 2018 will no longer qualify.
- Ralph Linne, Facilities Director, continued in 2018 and 2019 as a member of the CCAOSC Energy Executive Committee for the purchase of both natural gas and electric power for over 50 counties. Hamilton County has a contract with the CCAOSC through 2019 for natural gas and as part of our deregulated market strategy; a new five-year agreement has been approved through 2024 was approved by BOCC. There is also a five year agreement though 2023 for electrical power with CCAOSC with Dynegy as the supplier with a fixed rate which is the lowest rate we have had since bidding out electrical power.

The six major downtown buildings discussed in this report are responsible for a majority of utility usage and costs. However, the 3.2 million square feet managed or co-managed by the Facility Department also includes the following facilities: 264 William Howard Taft, 250 William Howard Taft, 911 Communication Center, Target Range, Coroner's Morgue and Crime Lab, Heliport, Public Works Garage, Sheriff Patrol Headquarters, and Winton Road Records Center. County Facilities does not provide all services in all these buildings; some have their own management, pay their own utility bills, or perform their own maintenance.

2 - 2019 Energy Outlook

The Facilities Department is continuing to proactively pursue enhanced building schedules, night setbacks, energy efficient equipment replacements, low-flush water fixtures, and low-wattage lighting replacements. Our forward-looking energy policy includes continuing the purchase deregulated electricity and natural gas, training building managers and staff, and utilizing Archibus and our engineering partner to identify and implement additional energy savings projects and strategies.

There are several main factors shaping Ohio's Energy Outlook the following key market influences should be watched:

- Duke and PUCO have agreed upon a settlement to retain the current Electric Securities Plan (ESP) or Standard Service Offer (SSO) for public use. This is critical for the stability of the local utility side of the bill (transmission & delivery, T&D) in the Duke Energy Territory. It is anticipated that prices will fluctuate through the beginning of 2019 as new riders approved in this agreement are incorporated, settling at a <2% increase in distribution charges through May 31, 2025.
- The CCAOSC Natural Gas broker agreement approved in 2019 should continue to provide price stability for natural gas commodity through 2024.
- The future impact of an increase in natural gas generating facilities and possible shutdown of nuclear power plants
- Possible change in PUCO policies with a new Governor and new director appointment in April 2019.

The figures on the following page include data from 230 East Ninth, 800 Broadway, County Administration Building, Alms & Doepke, Courthouse, and Justice Center, and indicate cost per unit and cost per year for electric, water, and natural gas for the Downtown Campus.

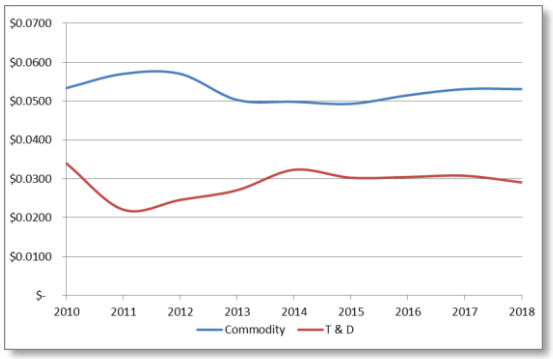


Figure 2-1. Electric costs per kWh

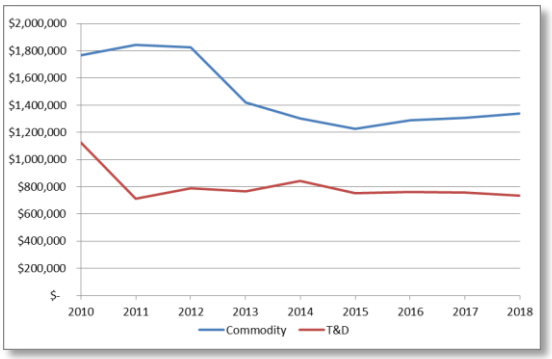


Figure 2-2. Electric costs per year

Electricity – Electrical Deregulation has decoupled electric bills into two main components: Commodity (the actual energy) and Transmission & Delivery (the cost to transport the energy). The Commodity portion is publicly bid out through an invitation to bid process to reduce cost in a three-year contract, while the T&D portion is regulated and cannot be bid out. We have little control over the T&D portion of the bill, but we see that T&D costs leveled off in the last couple of years.

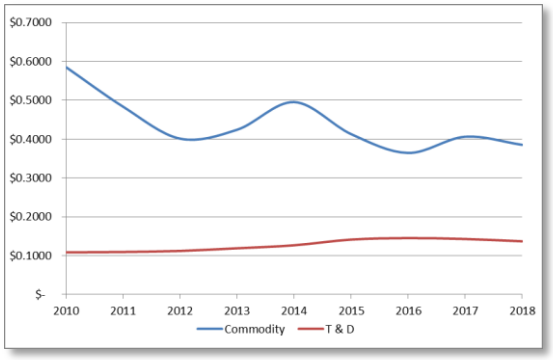


Figure 2-3. Natural gas costs per CCF

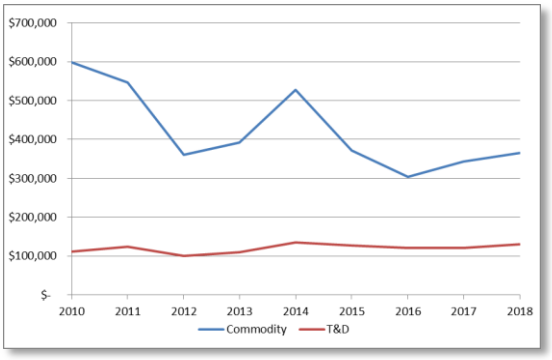


Figure 2-4. Natural gas costs per year

Natural Gas – This is also a deregulated market, with the same two components as electricity. The natural gas Commodity increased from 2012 to 2014, but has decreased since. The T&D unit cost has leveled off in the last couple of years. However, if this trend continues, it will significantly reduce the annual savings.

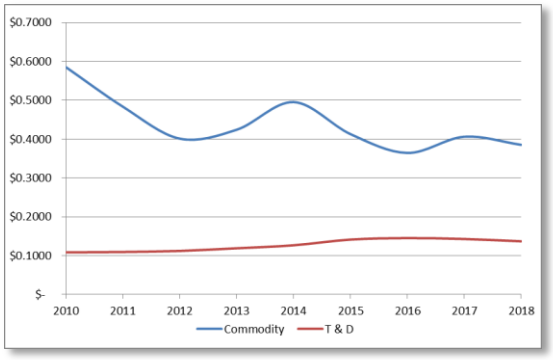


Figure 2-5. Water and sewer costs per kgal

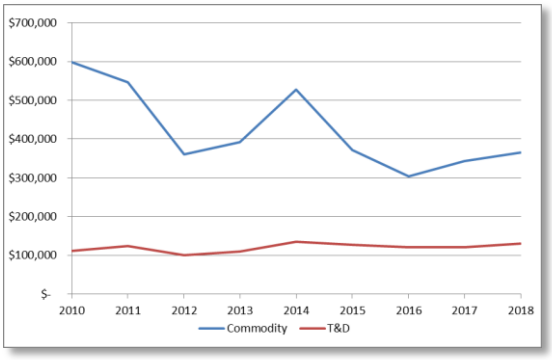


Figure 2-6. Water and sewer costs per year

Water and Sewer – Water and sewer unit costs remained very similar to those of 2017. Unit costs are anticipated to slightly increase as rates are raised by both the County and City.

3 - Vision Statement and Objectives

The Hamilton County Facilities Department will continue with an aggressive energy savings plan by utilizing the following strategies:

- Secure funding to update Energy Conservation Master Plan in 2020
- Continue energy management consulting services
  - Review electric, gas, and water usage monthly
  - Review electrical pulse meter data annually for large accounts
  - Monitor each building's energy usage and cost through Archibus and Energy Star Portfolio
  - Submit data for all major buildings to U.S. EPA to receive Energy Star Awards
- Pursue shared services in the area of energy procurement
  - Continue to procurement electricity through the CCAOSC.
    - The County's agreement with the CCAOSC Electricity Program is from 2019 through 2023.
  - Purchase deregulated natural gas through the CCAOSC
    - The County's new agreement with the CCAOSC Natural Gas Program is through March 2024.
  - The Director of County Facilities is a member of the CCAOSC Executive Committee and is directly involved in energy purchase approval that affects over 56 counties.
- Performance Contracting with Ameresco, Inc. was completed in 2015. Measurement and Verification was monitored quarterly for the first two years and will continue to be monitored annually through 2015.
- An RFQ is planned for issuance in 2019 to perform an energy audit to identify possible energy use reductions.
- Continue to eliminate inefficient use of energy systems
  - Purchase efficient major mechanical equipment (e.g. boilers, chillers, cooling towers) per County Life Cycle Cost Analysis Resolution
  - Participate in the Duke Energy Smart $aver energy efficiency program wherever possible.
  - Fully utilize the Energy Management Module inside the Archibus framework, which:
    - Shows results of the Performance Contracting Initiative with quantitative data
    - Generates monthly reports on targets, goals and usage compared to set baselines
    - Projects cost and usage increases as rate structures change
    - Monitors electric, water, and natural gas bills online to easily find and correct errors
  - Involve managers of County-owned buildings in tracking and reducing energy usage
  - Monitor electric, gas, and water usage on major equipment
  - Pursue energy-efficient building operations
    - Schedule night and weekend setback in unused spaces
    - Practice demand curtailing
    - Turn off all non-essential equipment when not in use

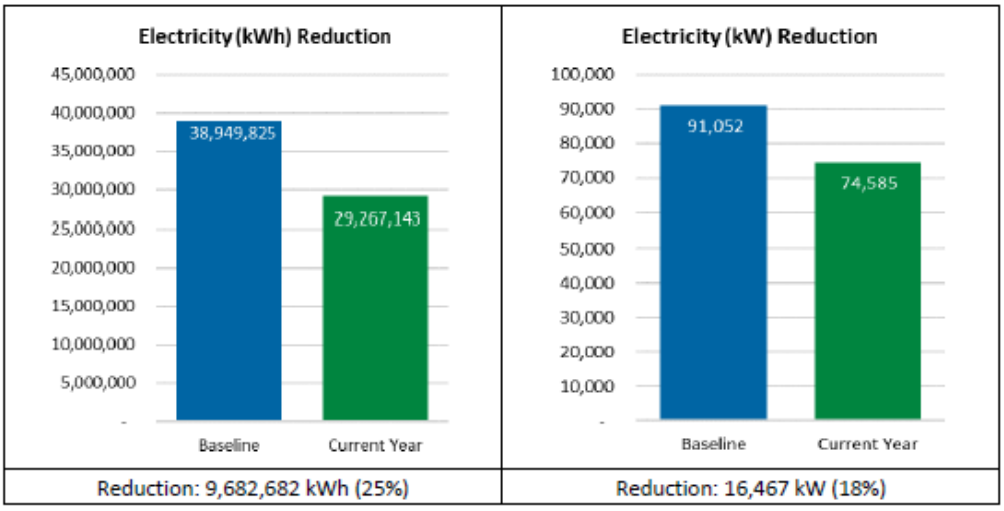
        - Set outdoor air dampers to minimum positions
        - Reduce lighting and other electrical loads
    - Secure a full-time Energy Manager position to manage energy usage and contracts and educate County employees about energy saving measures for work and home
- Stay on the leading edge of energy saving techniques and implementable solutions for public governments
    - Maintain Building Operations Certifications for Director, key staff, and building managers
    - Attend annual energy conferences and energy saving workshops to improve our energy savings strategies with new knowledge and techniques
    - Look into the certification of additional County buildings to the USGBC LEED-EB:O+M Silver Level standard where applicable per County Policy Directive.
    - Train and certify new building managers through the Midwest Energy Efficiency Alliance Building Operator Certification (BOC) program
    - Ensure that the new Crime Lab is designed, constructed, and managed to the most effective energy usage standards

4 - Performance Contracting

Performance Contracting work has been completed for three phases with Measurement and Verification reporting beginning in 2016. Below are some of the results from the various ECMs through Year 4 of the M&V Process.

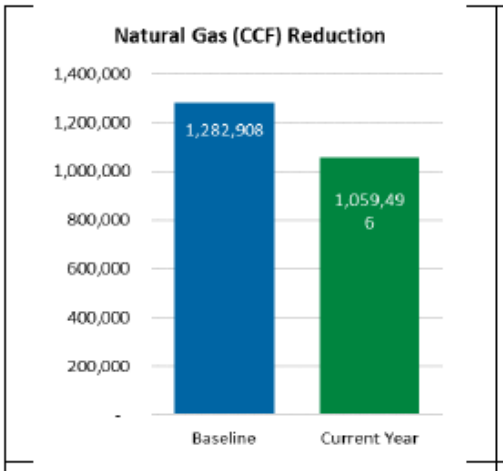
Utility Reduction Analysis								
Project Phase	Electric Energy Reduction (kWh/Yr)	Electric Demand Reduction (kW/Yr)	Natural Gas Reduction (CCF/Yr)	Water Reduction (kGal/Yr)	Electric Cost Reduction	Gas Cost Reduction	Water Cost Reduction	Total Cost Reduction
Phase 1	4,850,603	7,323	61,254	11,513	$399,455	$53,444	$103,223	$556,121
Phase 1A	3,712,052	7,464	182,910	6,701	$319,598	$133,572	$61,535	$514,704
Phase 2	1,120,028	1,680	(20,752)	1,108	$74,925	($14,204)	$9,614	$70,335
Totals	**9,682,682**	**16,467**	**223,412**	**19,322**	**$793,978**	**$172,811**	**$174,371**	**$1,141,160**

The total utility cost reduction is $1,141,160. The graphs on the following two pages show the overall energy and cost reductions by utility type.

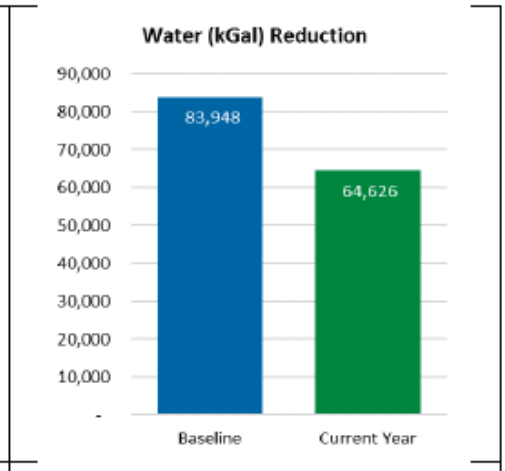


Reduction: 9,682,682 kWh (25%)

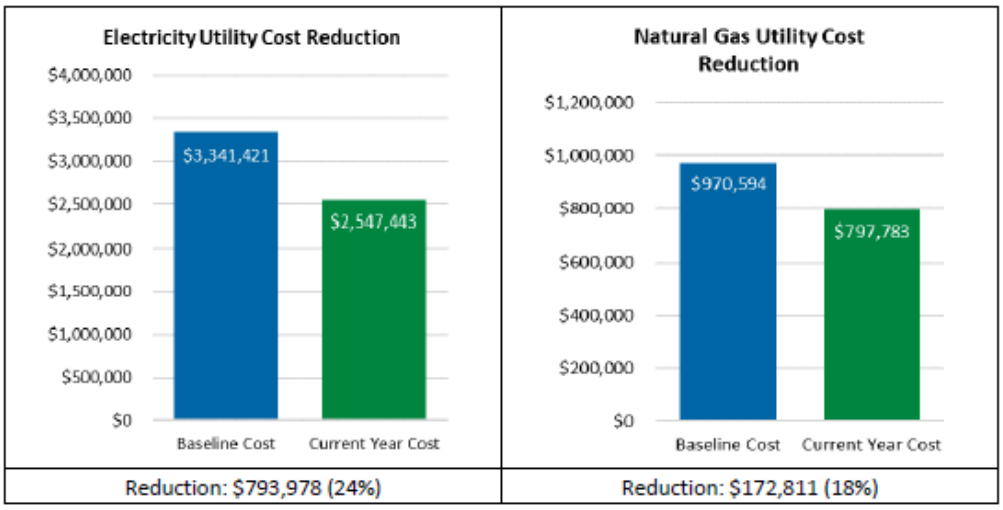
Reduction: 16,467 kW (18%)

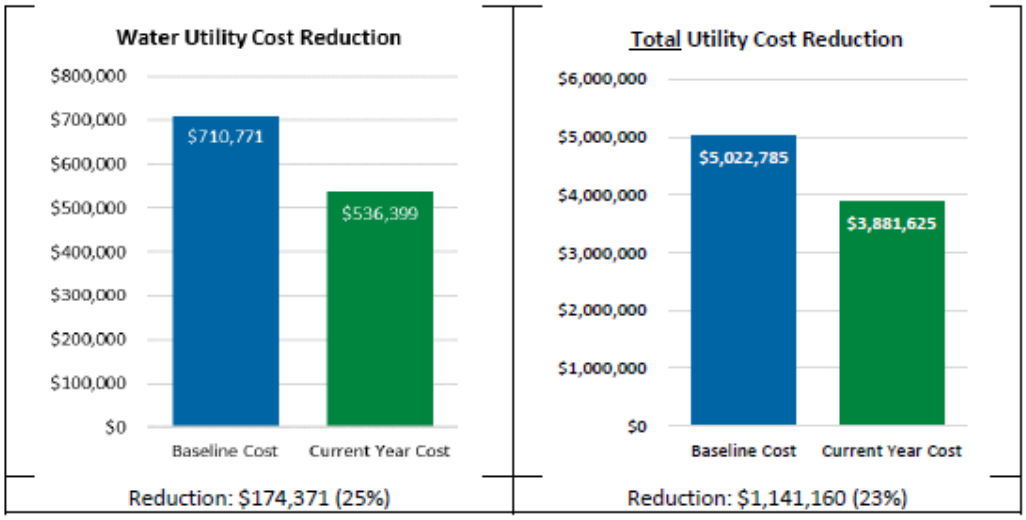


Reduction: 223,412 CCF (17%)



Reduction: 19,322 kGal (23%)


Electricity Utility Cost Reduction
$4,000,000
$3,500,000
$3,000,000
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$0
$3,341,421
$2,547,443
Baseline Cost
Current Year Cost
Reduction: $793,978 (24%)
Natural Gas Utility Cost Reduction
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$0
$970,594
$797,783
Baseline Cost
Current Year Cost
Reduction: $172,811 (18%)


Water Utility Cost Reduction
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
$710,771
$536,399
Baseline Cost
Current Year Cost
Reduction: $174,371 (25%)
Total Utility Cost Reduction
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
$5,022,785
$3,881,625
Baseline Cost
Current Year Cost
Reduction: $1,141,160 (23%)

5 - Energy Benchmarking and Usage

Energy Star Certifications

All major buildings were submitted to the Energy Star Portfolio, with updated and verified utility bills, square footage use, people counts, and computer counts. Energy Star uses this data to compare the energy performance of buildings nationwide on a 1 to 100 scale. Certification requires a score of 75 or higher, indicating that a building performs better than at least 75% of similar buildings.

The U.S. Department of Energy "Energy Star Program" uses the Commercial Building Energy Consumption Survey (CBECS) data to create the grading scale between similar building types. This data and the Energy Star metrics were updated, normalized and implemented in August 2018. At that time as predicted by Energy Star almost all sites saw a significant drop in their Energy Star scores (12-14 points for most offices). It's important note for Hamilton County that even though the Energy Star scores dropped in these buildings the energy usage per square foot typically remained the same or got better demonstrating that buildings are still performing well in actual energy usage. The first Figure below shows the old metrics; the second Figure shows the updated metrics for comparison.

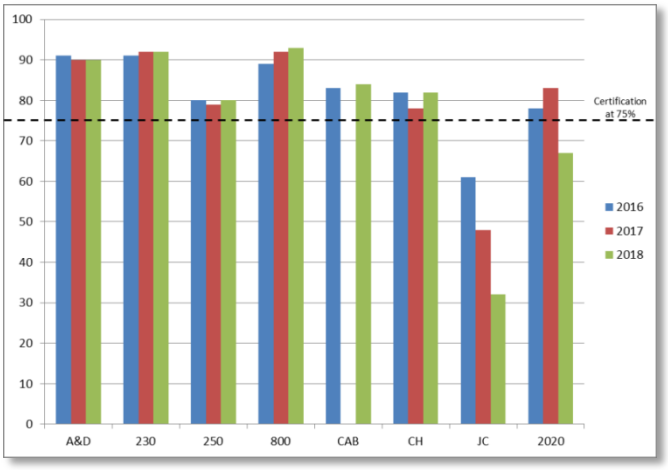


Figure 5-1. Energy Star scores with old metrics

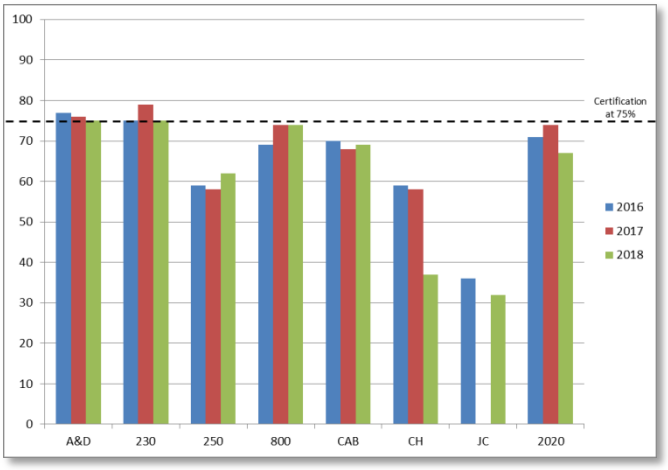


Figure 5-2. Energy Star new metrics (Aug 2018)

Since Energy Star has changed the 1-100 scoring we are accustomed to seeing, another way to monitor building performance is the Energy Use Index which is Energy Use per Square Foot. The last three years using this methodology is shown below, Lower is Better.

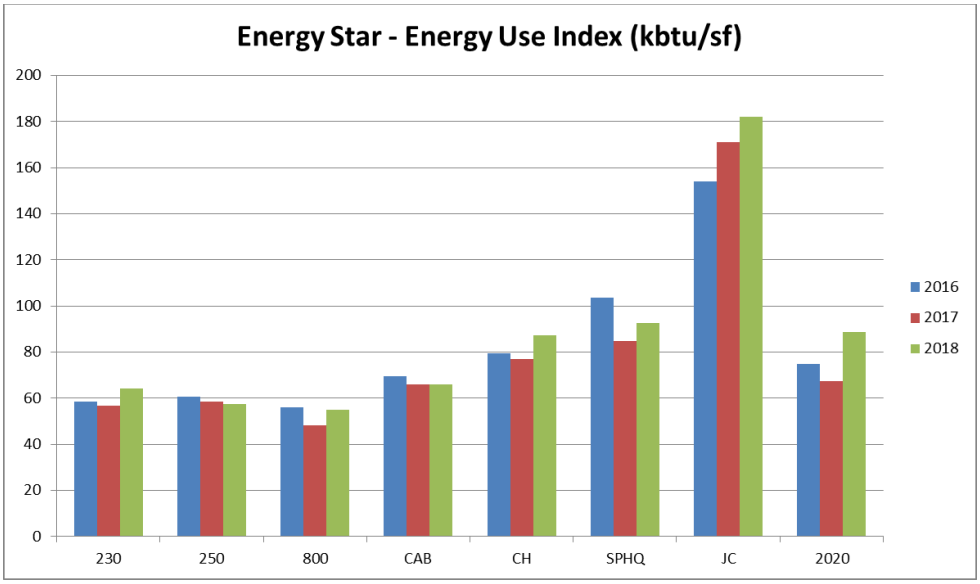


Table 5-1 - Energy Star Scores, 2012-2018

Buildings	2012	2013	2014	2015	2016	2017	2018	Notes
Jobs & Family (A&D)	57	67	**80**	**91**	**91**	**90**	**90**	2015 – 2018
230 East Ninth	71	**87**	**84**	**88**	**91**	**92**	**92**	2013 – 2018
250 William Howard Taft	**67**	54	**77**	**80**	**80**	**79**	**80**	2014 – 2018
800 Broadway	**88**	**86**	**87**	**85**	**89**	**92**	**93**	2009 – 2018
Administration	**97**	74	**79**	**86**	**83**	**83**	**84**	2011, 2012, 2014–2018
Courthouse	48	46	50	66	**82**	**78**	**82**	2016 – 2018
Sheriff Patrol HQ	30	20	24	35	39	57	**76**	2018
Justice Center	**85**	**90**	**94**	**88**	61	48	32	Jails do not qualify
Youth Detention (2020)	**79**	74	**76**	**79**	**78**	83	67	Jails do not qualify

**Scores in bold received certification. CH modeled as district steam plant for JC and scoring adjusted in 2016.*

Energy Use Index

Greenhouse Gas Emissions and Energy Use Index Results

Energy Star tracks the Greenhouse Gas Emissions and Energy Use Index charts automatically. The following charts indicate a slight increae in greenhouse gas emissions the last three years with a commensurate increase in energy usage per squrae foot for the Hamilton County Portfolio.

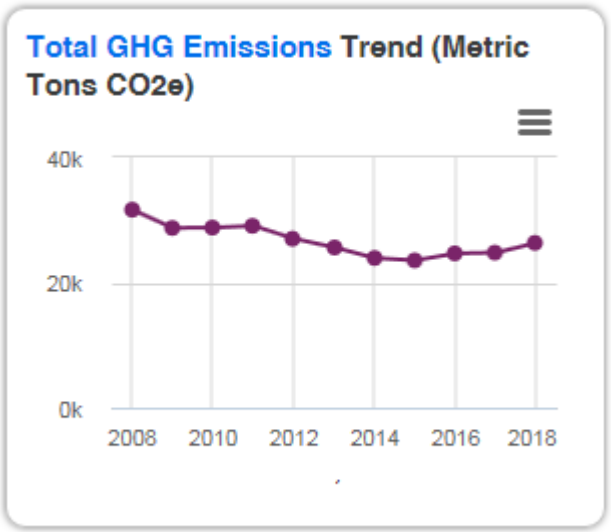


Figure 5-3. Total GHG Emissions

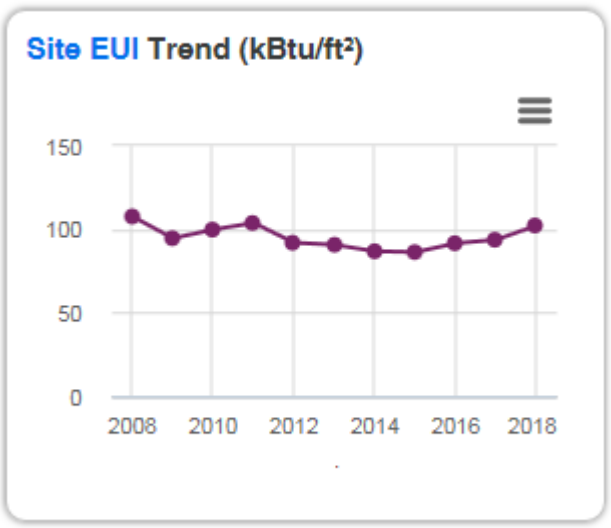


Figure 5-4. Site Energy Use Index

Energy Conservation Master Plan Results

The Energy Conservation Master Plan was implemented in conjunction with ThermalTech Engineering in 1998, updated in 2002 through the Rebuild America Grant, and then again in 2012 with Ameresco Performance Contracting. Over $23 million have been saved by these programs through

utility savings, avoided cost, rebates, refunds, grants, and bill reconciliations. Over $20 million of that sum is energy project savings through rates and usages, with $11.8 million in direct savings (bottom line utility bill payments). This corresponds to an annual savings to the taxpayer of $897,812 since the plan's inception.

U.S. Green Building Council LEED Certifications

LEED (Leadership in Energy & Environmental Design) is a green building certification program that recognizes best-in-class building strategies and practices.

- Secure LEED Certified level for the design/construction of a new morgue and crime lab per BOCC policy.
- In 2014, the 800 Broadway building qualified as the first County-level government building in Ohio to receive LEED Existing Buildings: Operations and Maintenance (LEED-EB:O+M) certification, which was valid through 2018.

Annual Cost & Usage Summaries

Figure 5-5 displays utility cost by type for the last three years. Figure 5-6 shows the total cost for 2018 broken down by building. Note that the Justice Center and Courthouse buildings accounted for 48% of utility costs in 2018.

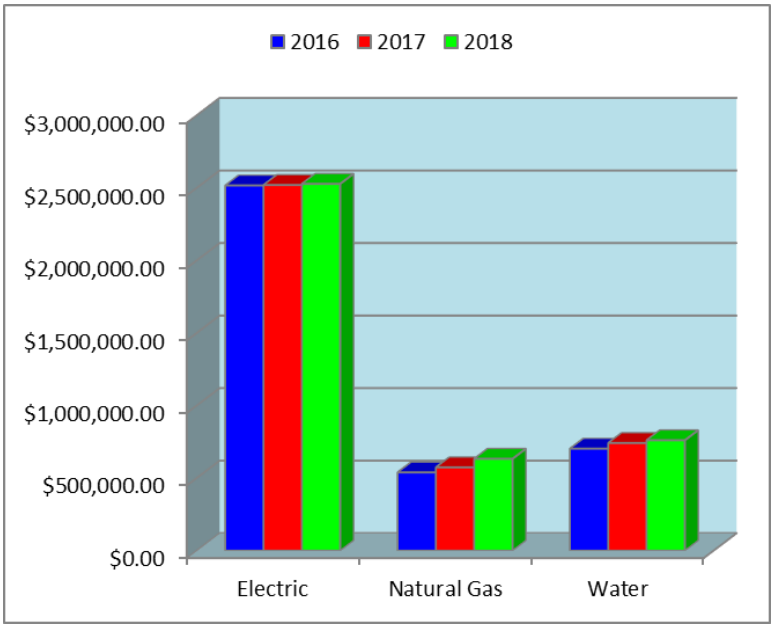


Figure 5-5. Total annual utility costs

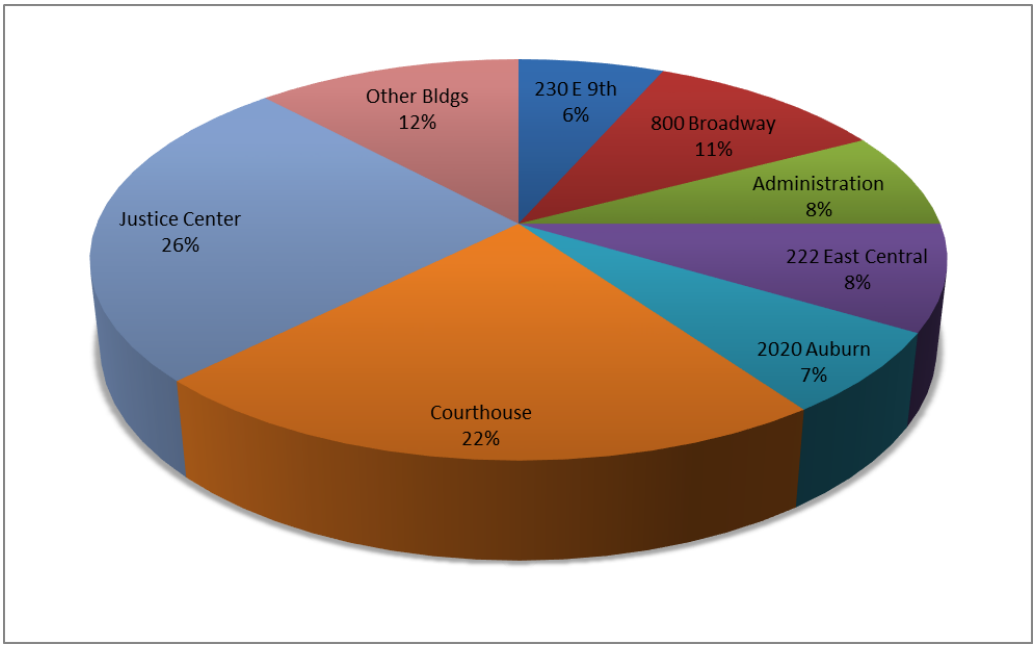


Figure 5-6. Total 2018 utility cost by building

Electricity

As shown in Figure 5-7, electricity consumption in 2018 was more favorable than previous years in most of the transition months. Summertime energy consumption was generally higher. Figure 5-8 shows the steady decrease in annual electric usage from 2012 may be leveling off. Neither datasets are normalized for degree days.

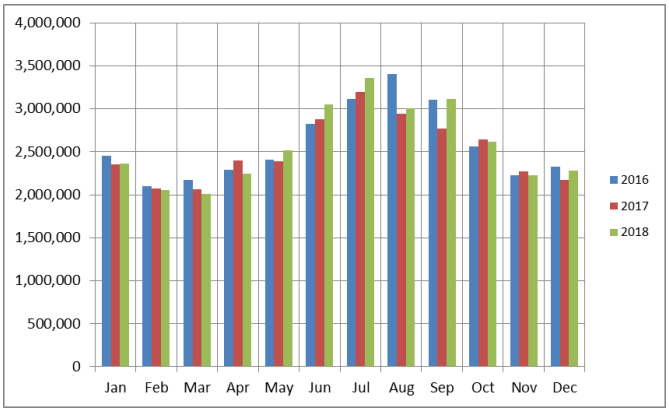


Figure 5-7. Total electric usage (kWh) 3 Yr Avg

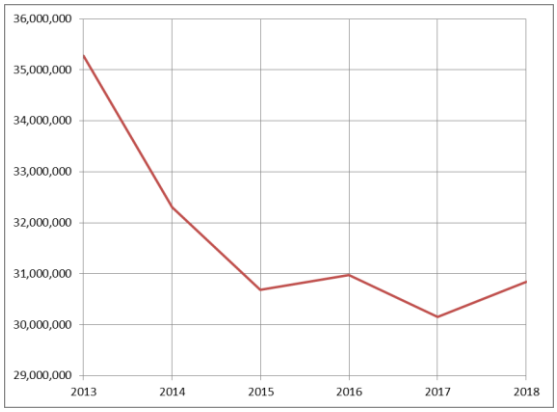


Figure 5-8. Annual Electric Usage All Buildings in kWh (2013 through 2018)

Figure 5-9 through Figure 5-13 below compare electric usage for 2017 and 2018.

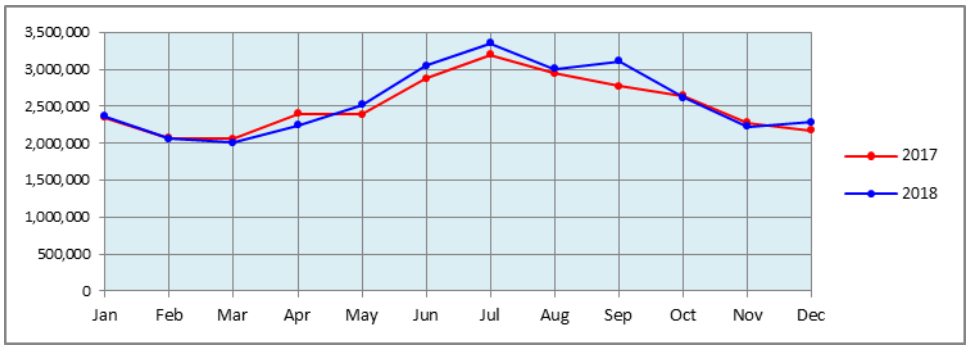


Figure 5-9. Total electric usage in kWh by month, 2017 and 2018

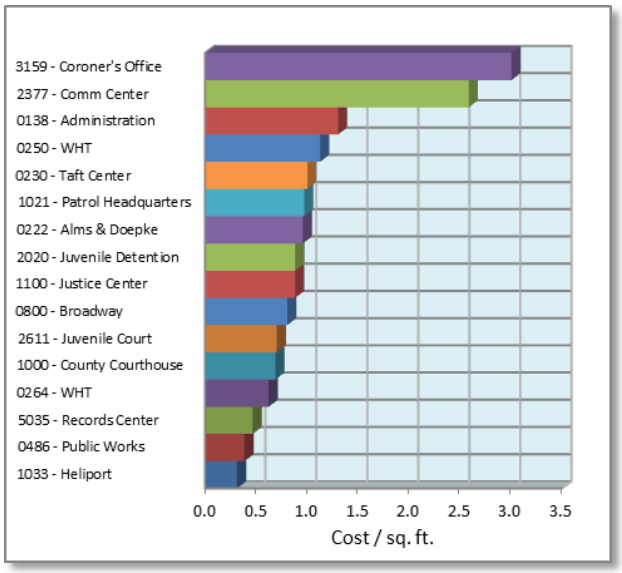


Figure 5-10. Electric cost per square foot by building, 2017

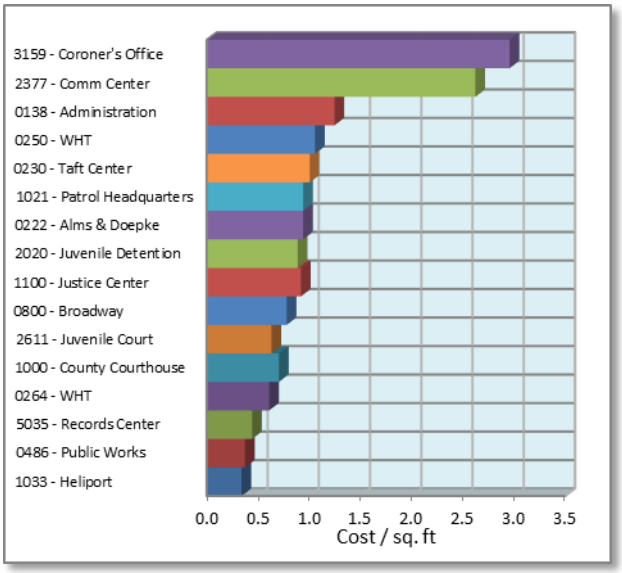


Figure 5-11. Electric cost per square foot by building, 2018

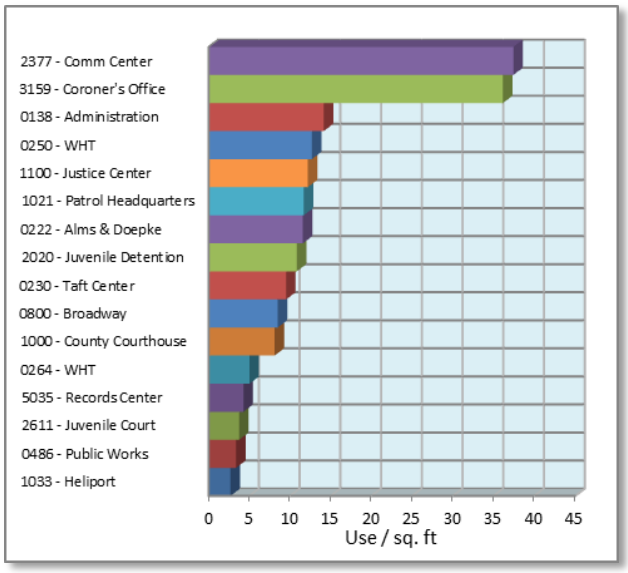


Figure 5-12. Electric usage (kWh) per square foot by building, 2017

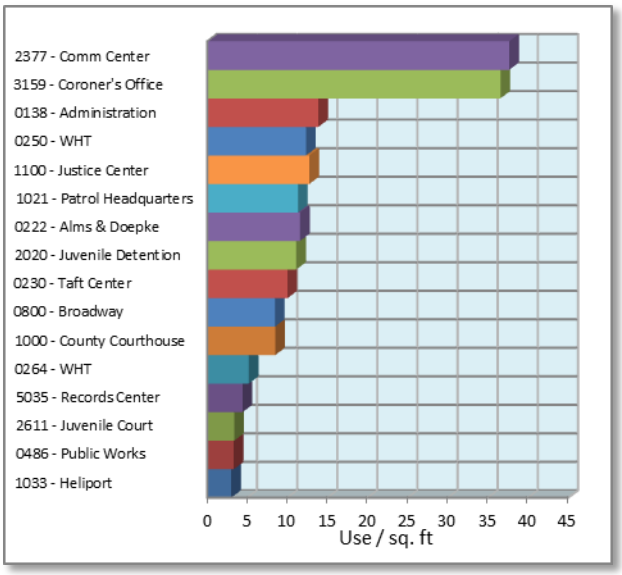


Figure 5-13. Electric usage (kWh) per square foot by building, 2018

Natural Gas

Natural gas consumption rose in 2018 (see Figure 5-15) largely due to high consumption in the beginning of the year (see Figure 5-14).

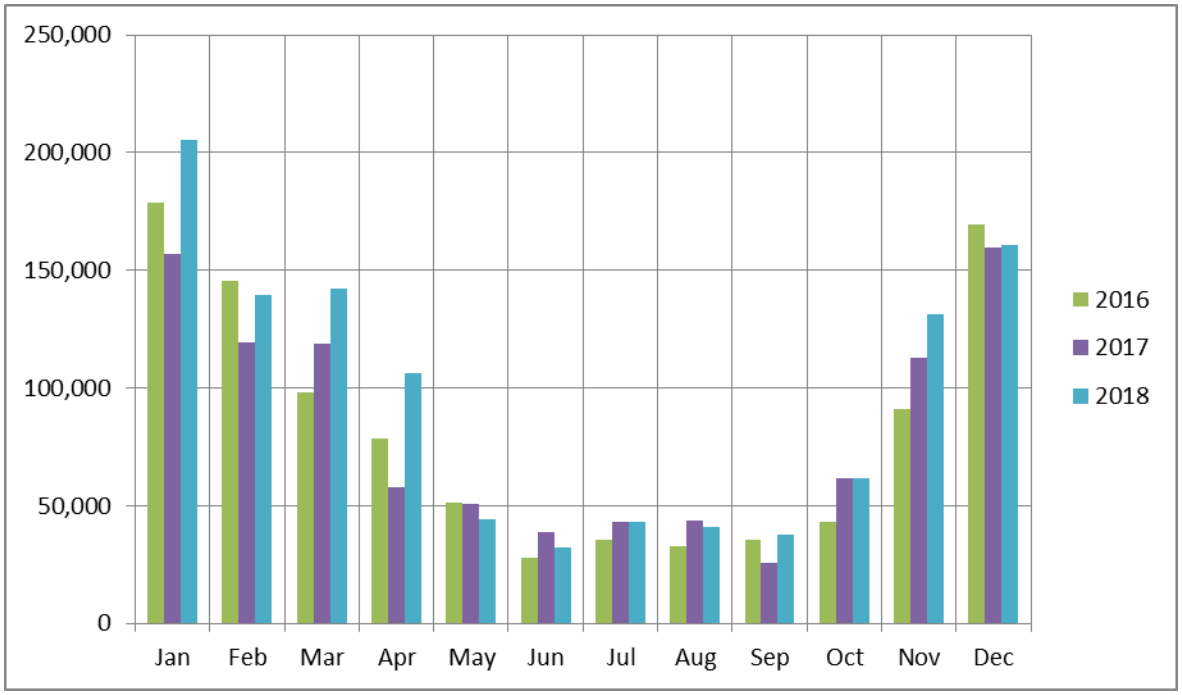


Figure 5-14. Total natural gas usage (ccf) three-year comparison by month

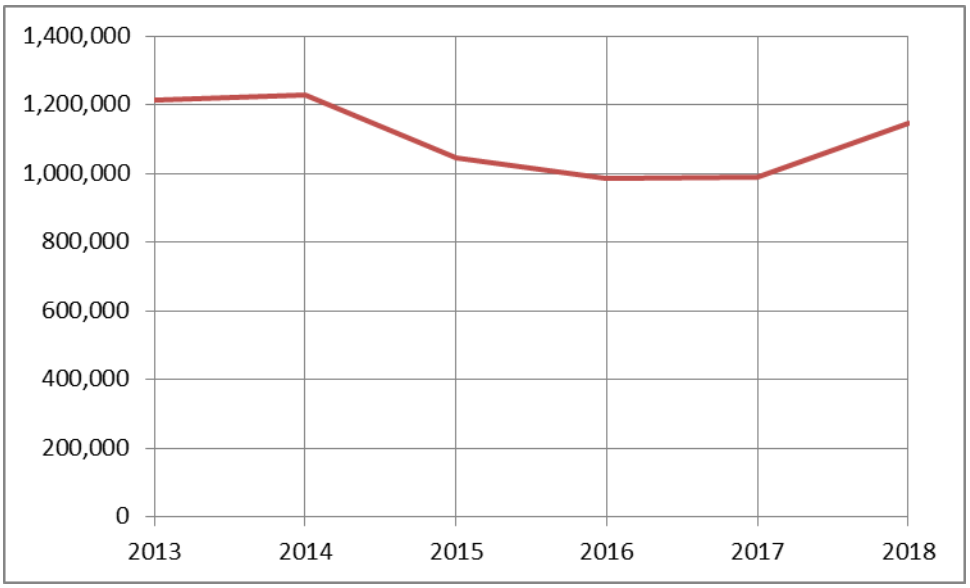


Figure 5-15. Annual total natural gas usage in ccf, 2013-2018

Figure 5-16 through Figure 5-20 below compare natural gas usage for 2017 and 2018. Natural gas use and cost per square foot increased for each building, except the Justice Center's cost.

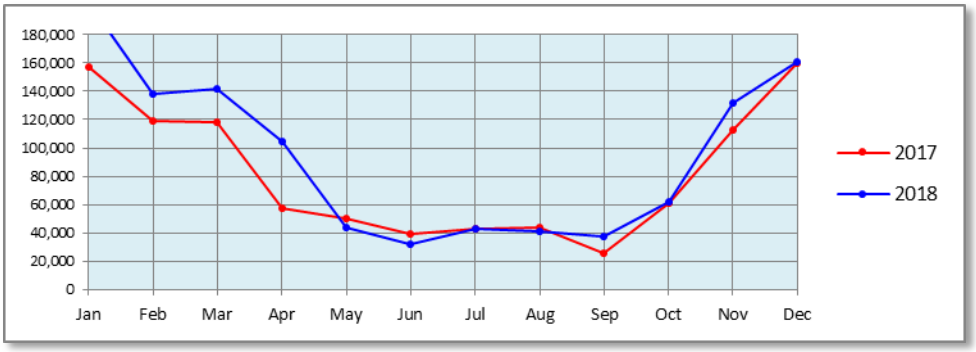


Figure 5-16. Total natural gas usage in ccf by month, 2017 and 2018

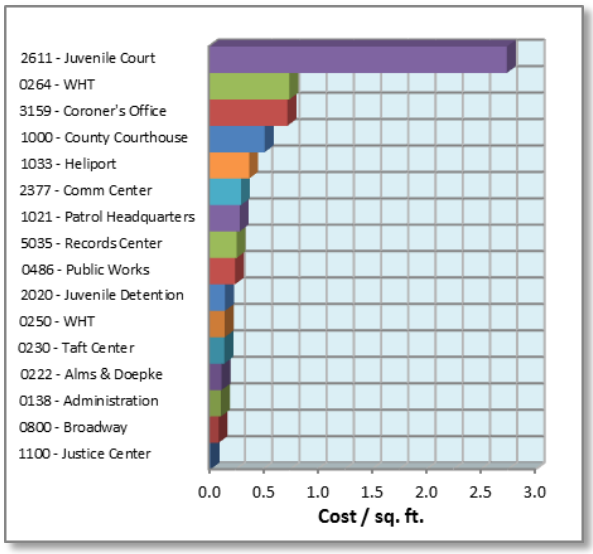


Figure 5-17. Natural gas cost per square foot by building, 2017

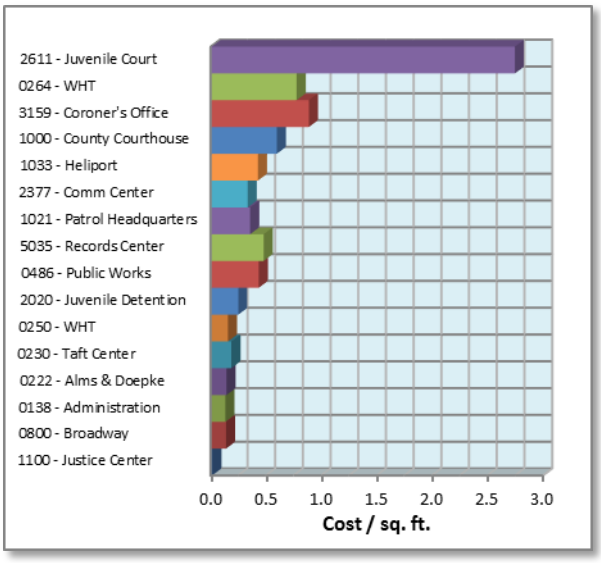


Figure 5-18. Natural gas cost per square foot by building, 2018

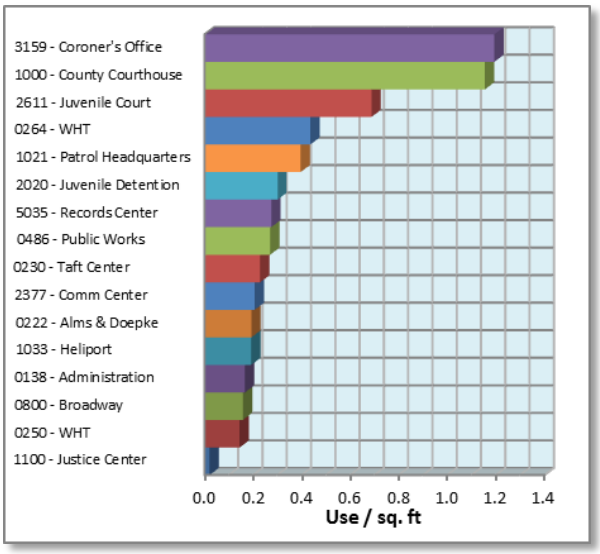


Figure 5-19. Natural gas usage (ccf) per square foot by building, 2017

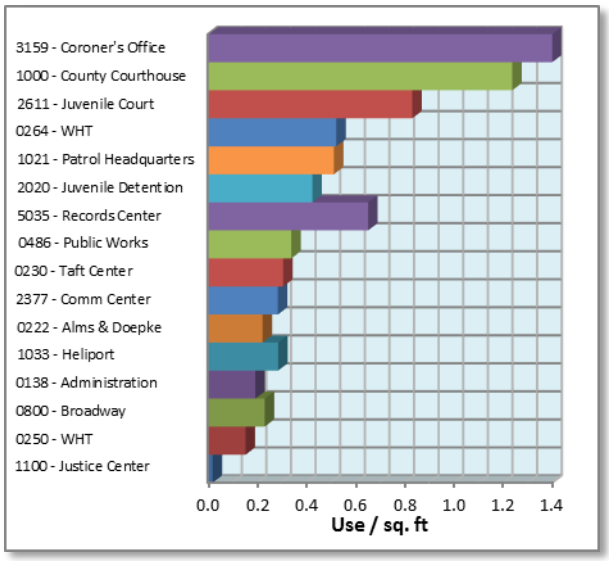


Figure 5-20. Natural gas usage (ccf) per square foot by building, 2018

Water Usage

Water consumption rose slightly, with increased consumption throughout most of the year. Usage is similar to 2014.

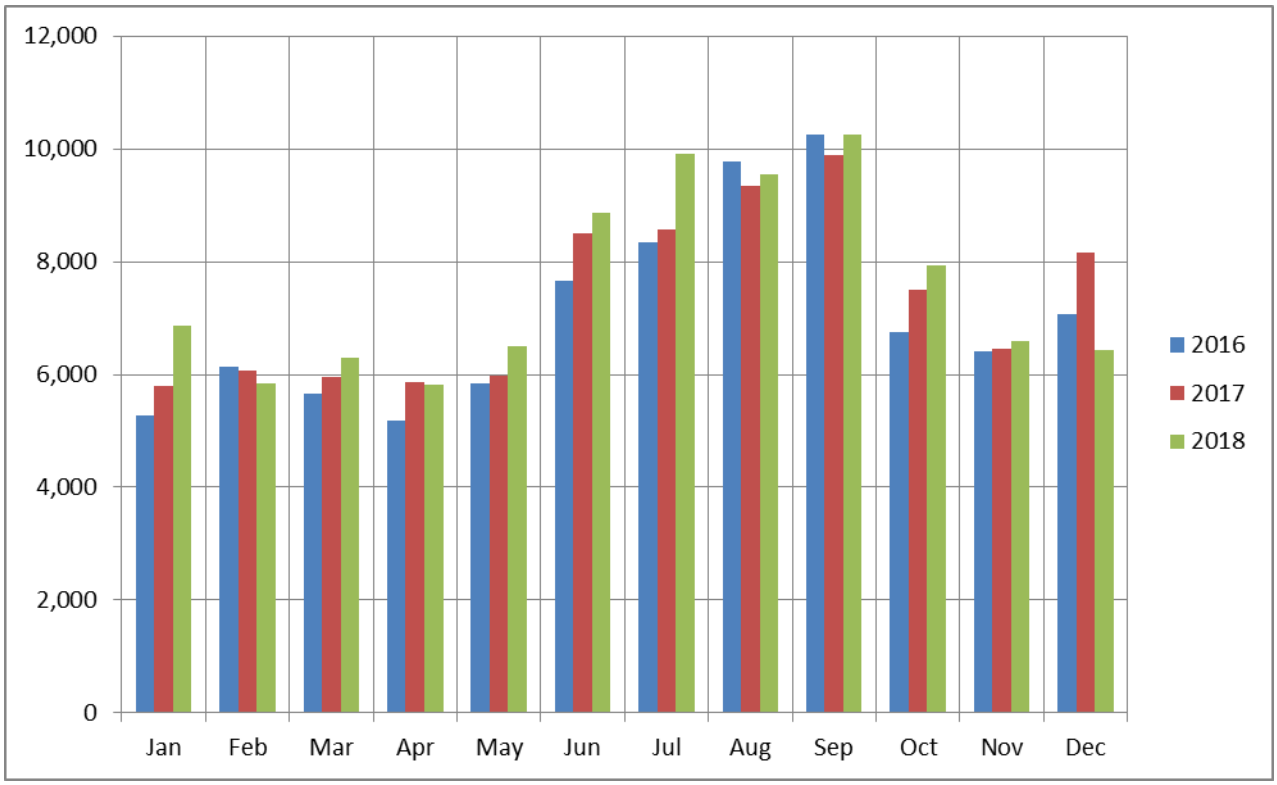


Figure 5-21. Total water usage (ccf) three-year comparison by month

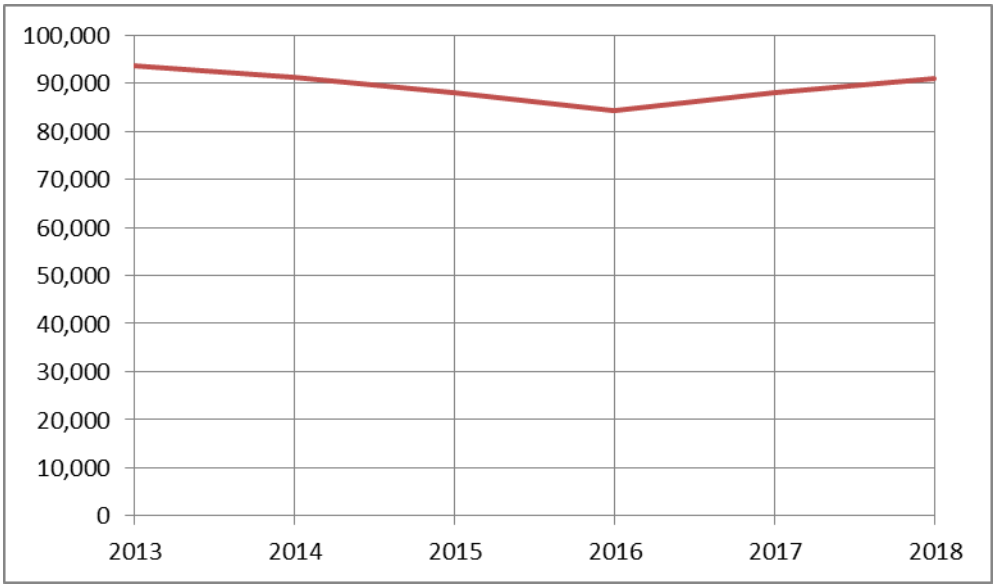


Figure 5-22. Annual total water usage in ccf, 2013-2018

Figure 5-23 through Figure 5-27 below compare water usage for 2017 and 2018.

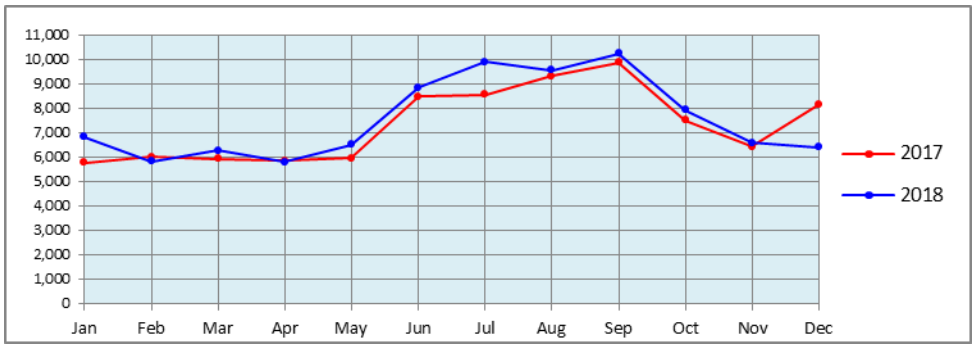


Figure 5-23. Total water usage in ccf by month, 2017 and 2018

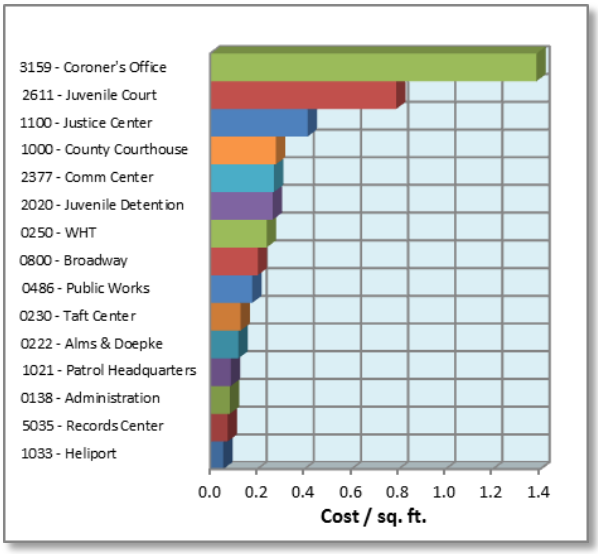


Figure 5-24. Water cost per square foot by building, 2017

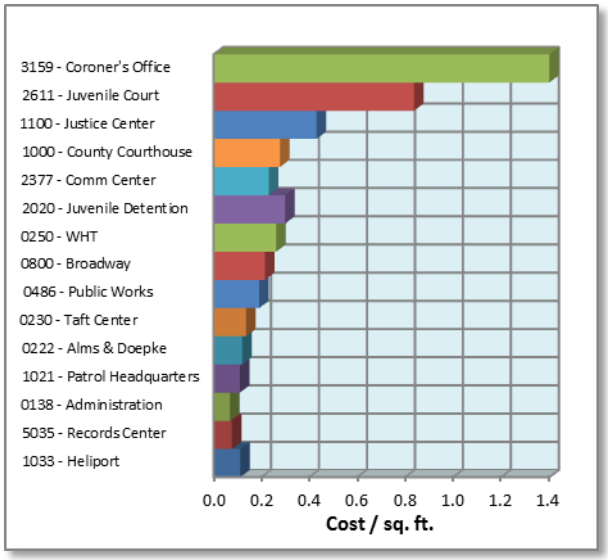


Figure 5-25. Water cost per square foot by building, 2018

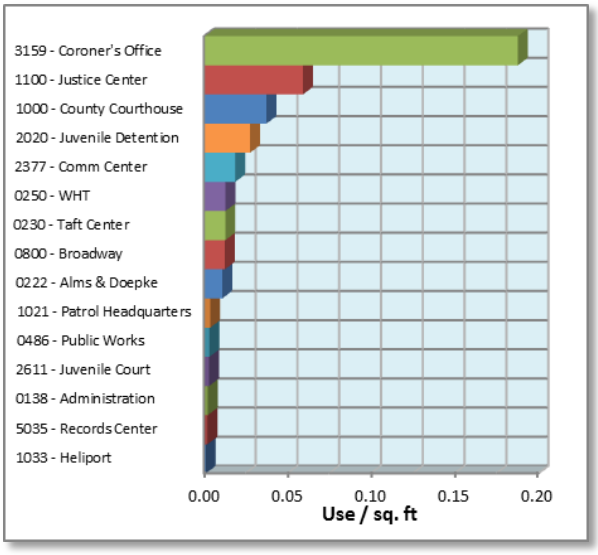


Figure 5-26. Water use (ccf) per square foot by building, 2017

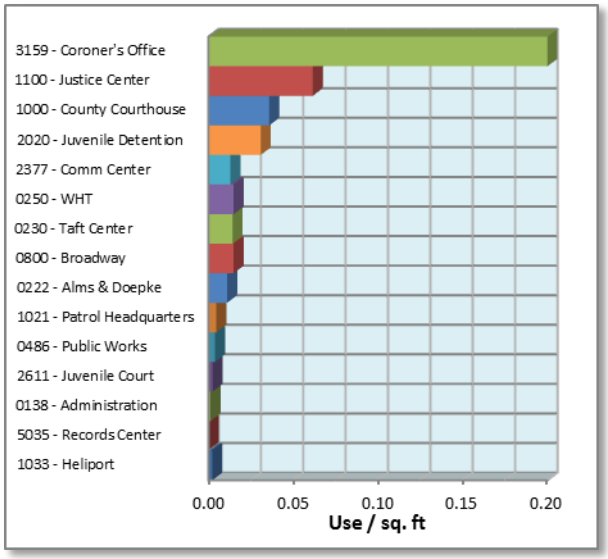


Figure 5-27. Water use (ccf) per square foot by building, 2018

6 - Cost-Saving Measures

Deregulated Electricity Commodity Purchasing

In 2015, County Facilities bid out the Provision of Electric Power through a public bid process (invitation to bid) for another three-year term. This bid was open to all Certified Electric Suppliers approved in the Duke Energy Territory. Dynegy Energy Services was the best bidder for fixed rate offers for the Facilities Department in this period. Other county agencies were allowed to "piggyback" on this invitation to bid, and they also signed with Dynegy Energy Services. These agencies include Stadia & Parking, DDS, and County Engineer. Service began for all sites on the first billing cycle in 2016.

- January 1, 2010–December 31, 2012: the first "Deregulated Commodity Contract" was awarded to Duke Energy Retail Service (DERS) with an electric rate of $0.0570 per kWh at a three-year fixed price contract, avoiding a cost of $1,750,695 in its three-year period.
- January 1, 2013–December 31, 2015: yhe First Energy price locked in at $0.0493 cents per kWh, yielding a three-year savings total of $906,175.
- January 1, 2016–December 31, 2018: the Dynegy fixed price bid locked in at an average of $0.0528 per kWh for Facilities, yielding a three-year savings total of $393,460.

Table 6-1. Electric broker vs. local utility comparison for Facilities Department only

Year	Usage (kwh)	Non-Shopper Cost ($)	Shopper Cost ($)	Savings (Annual)	Accumulated Savings
2010	38,283,754	$ 3,970,566	$ 3,195,133	$ 775,433	$ 775,433
2011	35,831,797	$ 3,739,180	$ 2,798,953	$ 940,227	$ 1,715,660
2012	34,568,328	$ 2,845,793	$ 2,810,759	$ 35,035	$ 1,750,695
2013	32,584,898	$ 2,778,860	$ 2,459,886	$ 318,974	$ 2,069,669
2014	29,874,979	$ 2,685,077	$ 2,382,805	$ 302,272	$ 2,371,941
2015	26,800,137	$ 2,408,236	$ 2,123,307	$ 284,929	$ 2,656,870
2016	27,026,985	$ 2,356,754	$ 2,101,938	$ 254,816	$ 2,911,686
2017	30,155,280	$ 2,321,381	$ 2,260,767	$ 60,614	$ 2,972,300
2018	30,839,428	$ 2,434,973	$ 2,356,942	$ 78,031	$ 3,050,331
			Accumulated Savings Total >>		**$ 3,050,331**

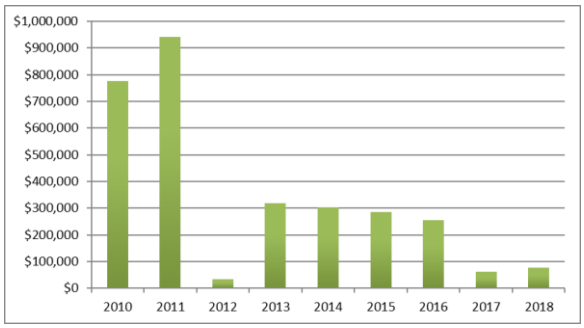


Figure 6-1. Electric annual savings

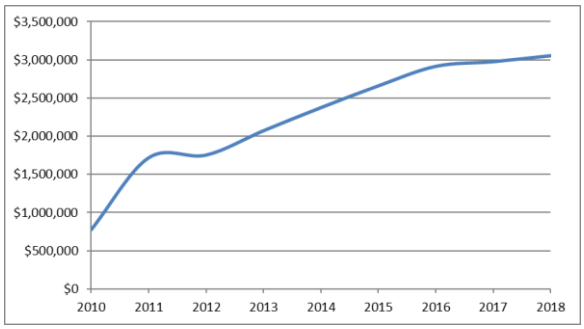


Figure 6-2. Electric accumulated savings

The savings above only include the "commodity" savings, excluding the generation savings. In this report, the generation savings are considered an avoided cost, as they are a cost never experienced by the County because of its proactive approach of purchasing deregulated electricity early in the process. All charts were updated for all buildings in the portfolio this year.

Hamilton County Natural Gas Broker Agreement

This program was put in place in 2000, with an agreement between the County and the County Commissioners' Association of Ohio Service Corp (CCAOSC). The CCAOSC manages a third-party gas marketer that aggressively buys natural gas on the open market with strategies that are intended to provide the best gas prices with a manageable risk. Monthly totals vary between savings and expenditures, but overall the plan is successfully saving money.

Table 6-2. Natural gas commodity vs. Duke GS rate showing Facilities Department saving only

Year	Gas Usage (mcf)	Commodity Cost	Duke Cost	Savings (Annual)	Accumulated Savings
2010	128,797	$ 744,235	$ 831,818	$ 87,583	$ 87,583
2011	125,883	$ 674,381	$ 724,025	$ 49,644	$ 137,227
2012	110,575	$ 456,888	$ 545,108	$ 88,220	$ 225,447
2013	121,288	$ 509,038	$ 632,759	$ 123,721	$ 349,168
2014	122,917	$ 618,991	$ 709,977	$ 90,986	$ 440,154
2015	104,448	$ 429,622	$ 537,675	$ 108,053	$ 548,207
2016	98,720	$ 363,149	$ 427,293	$ 64,145	$ 612,352
2017	98,850	$ 405,907	$ 500,302	$ 94,395	$ 706,747
2018	114,460	$ 444,510	$ 533,903	$ 89,392	$ 796,139
				Accumulated Savings Total:	***$ 796,139***

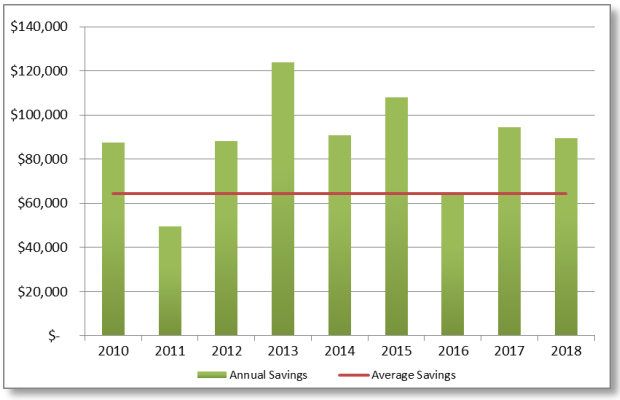


Figure 6-3. Gas broker annual savings, $/MCF

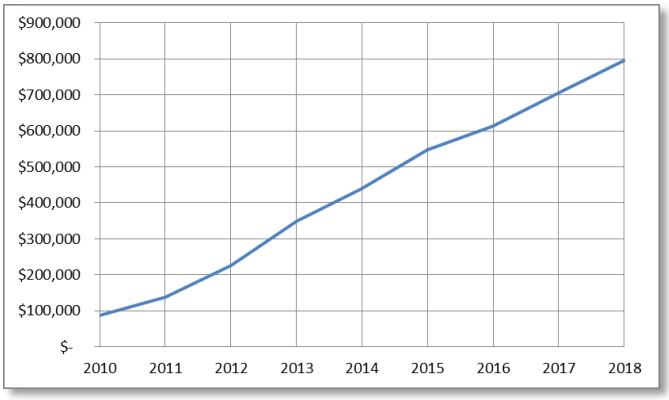


Figure 6-4. Gas broker accumulated savings

As with any open market commodity purchase plan, there is always risk on a year-to-year basis. However, savings continues to accumulate.

Courthouse Interruptible Tariff (IT) Savings

This program was put in place in 2003 and was ready for 2004 usage. An agreement exists between the end user and the local utility (Duke Energy Ohio) that stipulates that, in exchange for lower rates, natural gas service can be curtailed during high demand times. To qualify, the end user must use at least 1,000 MCF during the summer months. The Courthouse meets this requirement because it provides steam to the Justice Center. Table 6-3 shows the accumulated savings of this plan.

Table 6-3. Courthouse IT vs. FT rate comparison

Year	Gas Usage CCF	Firm Cost	Interruptible Cost	Curtailment Cost	Annual Savings	Accumulated Savings
2004	957,232	$147,918	$54,208	$0	$93,710	**$93,710**
2005	938,086	$144,969	$58,271	$0	$86,698	**$180,408**
2006	866,570	$133,956	$49,751	$0	$84,205	**$264,613**
2007	876,079	$135,420	$50,218	$0	$85,202	**$349,815**
2008	880,728	$157,511	$62,663	$0	$94,847	**$444,662**
2009	832,908	$144,772	$65,902	$0	$78,870	**$523,532**
2010	831,541	$118,086	$72,139	$0	$45,947	**$569,478**
2011	859,877	$119,445	$72,083	$0	$47,362	**$616,840**
2012	735,889	$106,063	$66,531	$0	$39,532	**$656,373**
2013	779,994	$108,849	$72,194	$26,642	$10,013	**$666,386**
2014	732,410	$109,200	$72,802	$38,116	-$1,718	**$664,668**
2015	634,487	$95,211	$68,540	$0	$26,671	**$691,339**
2016	601,268	$85,342	$67,492	$0	$17,850	**$709,189**
2017	639,088	$85,190	$71,085	$2,610	$11,495	**$720,684**
2018	685,201	$92,191	$74,448	$0	$17,743	**$738,427**
Total	11,851,358	$1,784,123	$978,328	$67,368	$738,427	**$738,427**

Starting in 2013, a column was added for curtailment cost. The Courthouse was curtailed by Duke Energy multiple times in 2013 & 2014, zero times in 2015 & 2016, twice in 2017, and not in 2018.

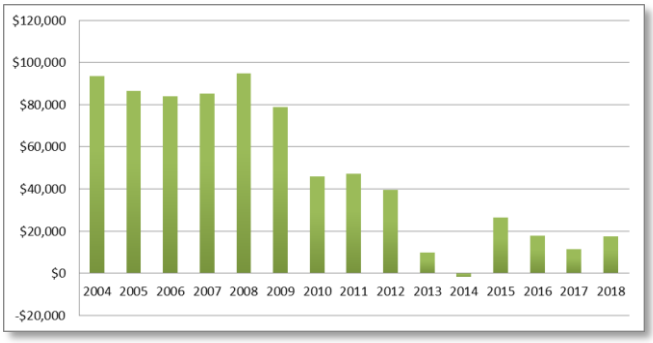


Figure 6-5. Courthouse annual IT savings

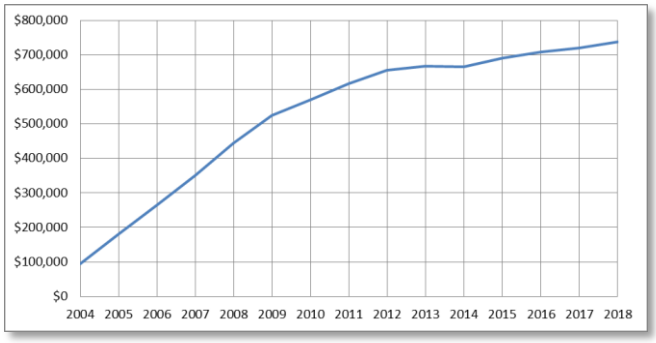


Figure 6-6. Courthouse accumulated IT savings

Facilities will periodically review the necessity of this program and search for alternatives that may result in greater savings. This program currently costs nothing to maintain, so all savings are beneficial. Although this program has saved over a half million dollars historically, annual savings have decreased in recent years. Some of the reduction in savings is due to improved natural gas consumption—lower consumption results in lower overall costs. Curtailment in 2014 reduced savings by 11%, putting the program in negative savings for the first time ever; however, there was less curtailment in 2015, resulting once more in positive savings. As the Firm Transport Cost decreases and the Interruptible Cost remains the same with decreasing consumption, leaving the program and going back to Firm Transport gas may provide little to no additional cost in exchange for the lower risk rate tariff and no curtailment.

7 - Building Utility Tracking Graphics

The following tables, figures, charts, and graphs are tools used to study, verify, and predict usage in the County Facilities Portfolio of buildings. They concentrate specifically on the detailed performance of each building, and each section provides an itemized review of the more general findings presented earlier in this report.

Although the overall energy usage and cost data include all Facility-managed buildings, this section focuses on only the major contributors to the total energy footprint:

- 230 East 9th (William Howard Taft Law Center)
- 250 William Howard Taft
- 800 Broadway Building
- County Administration Building
- Alms & Doepke (Jobs & Family Services)
- Hamilton County Courthouse
- Hamilton County Justice Center
- Juvenile Detention Center (2020 Auburn)

Each building section is comprised of the following data:

- Building profile from Archibus, including building footprint, square footage, construction type, year built, number of floors, fire sprinkler status, etc.
- Annual electric, gas, and water usage charts with comments
- Three-year hourly electric demand review, with special attention given to summary and winter trends, and comments identifying successes and areas of focus for upcoming year.
- Energy Star review of the current status of each property in the Energy Star Portfolio Manager program, with additional comments provided by Facilities and ThermalTech Engineering.
    - Energy Star Score, current versus baseline
    - Historical greenhouse gas (GHG) emission trends
    - Historical Source Energy Use indices (EUI).
    - Metrics summary of changes from the baseline year to the current year

230 East 9th (William Howard Taft Law Center)



Bldg Code:	0230
Address :	230 East Ninth Street
City :	CINCINNATI
State :	OH
Postal Code:	45202
Site Code :	COUNTYCAMPUS
Agency :	HC ADMIN
Use :	Office
Const Type:	BrickStone
Date Built :	1925
Ext Gross Area:	193,524.65 sf
Int Gross Area:	184,591.21 sf
Rentable Area:	172,189.70 sf
Estimated Area:	0.00 sf
Total Roof Area:	15,111.27 sf
Leased/Owned :	Owned
Floor Count :	16
Sprinklered? :	Yes
Property :	079-0002-0008-00

Fl Code	Int Gross	Ext Gross	Vert Pen	Service	Rentable	Usable	Room Area
01	13.655 sf	14.439 sf	1.395 sf	2.961 sf	12.260 sf	9.300 sf	13.655 sf
02	13,836 sf	14,482 sf	932 sf	3,442 sf	12,904 sf	9,462 sf	13,807 sf
03	13,794 sf	14,503 sf	907 sf	2,160 sf	12,886 sf	10,727 sf	13,807 sf
04	13,741 sf	14,502 sf	842 sf	1,797 sf	12,898 sf	11,101 sf	13,741 sf
05	13,848 sf	14,503 sf	880 sf	1,802 sf	12,967 sf	11,165 sf	13,848 sf
06	13,895 sf	14,503 sf	903 sf	1,572 sf	12,992 sf	11,420 sf	13,895 sf
07	13,775 sf	14,498 sf	897 sf	1,490 sf	12,878 sf	11,389 sf	13,775 sf
08	13,895 sf	14,503 sf	850 sf	1,613 sf	13,045 sf	11,432 sf	13,895 sf
09	13,890 sf	14,503 sf	883 sf	2,222 sf	13,007 sf	10,785 sf	13,890 sf
0B	14,480 sf	15,049 sf	785 sf	7,360 sf	13,696 sf	6,336 sf	14,480 sf
0P	2,488 sf	2,647 sf	242 sf	2,246 sf	2,246 sf	-0 sf	2,488 sf
10	13,880 sf	14,503 sf	915 sf	2,030 sf	12,965 sf	10,935 sf	13,880 sf
11	13,883 sf	14,503 sf	914 sf	1,451 sf	12,969 sf	11,518 sf	13,883 sf
12	13,825 sf	14,503 sf	912 sf	2,179 sf	12,914 sf	10,734 sf	13,825 sf
SB	1,706 sf	1,886 sf	144 sf	1,562 sf	1,562 sf	0 sf	1,706 sf

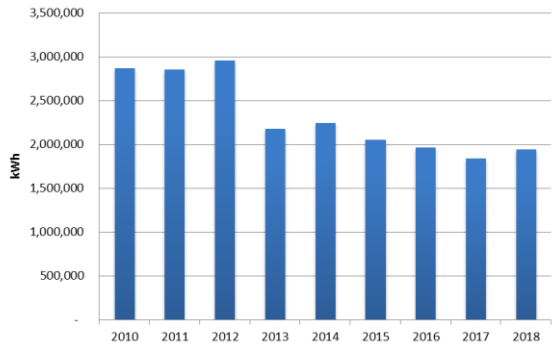


Figure 7-1. 230 East 9th – annual electric usage

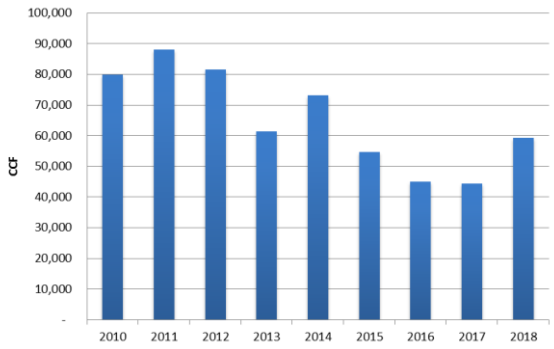


Figure 7-2. 230 East 9th - annual gas usage

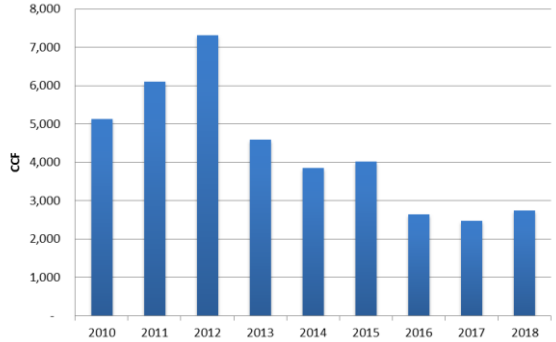


Figure 7-3. 230 East 9th - annual water usage

Electric – slight increase over previous year, but otherwise at several year low

Natural Gas – increase over previous years

Water – slight increase over previous years

230 East 9th - Hourly Demand Review

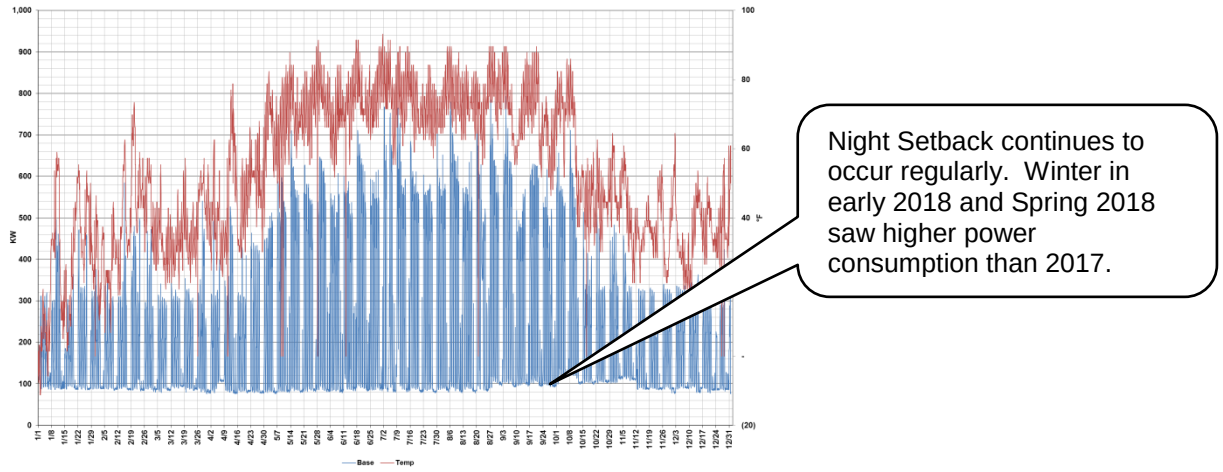


Figure 7-4. Hourly electric data – 230 E 9th (2018)

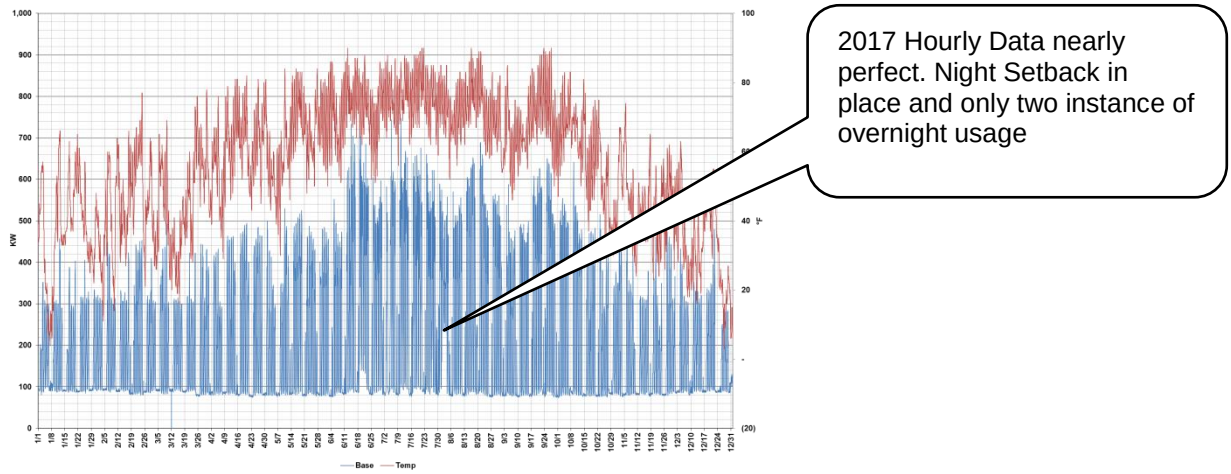


Figure 7-5. Hourly electric data – 230 E 9th (2017)

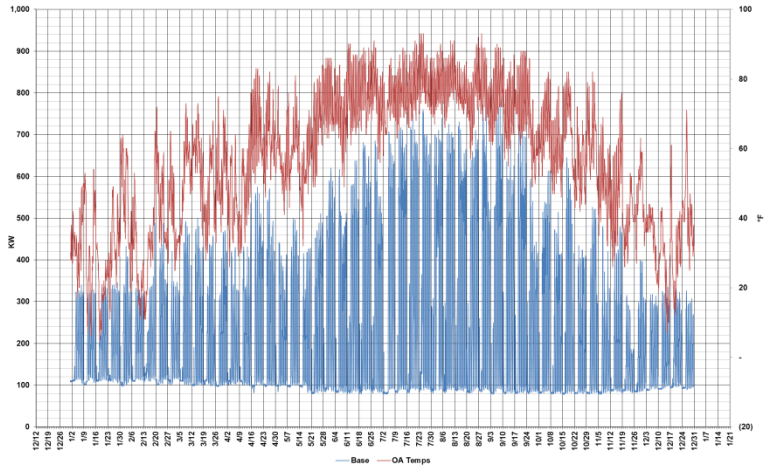
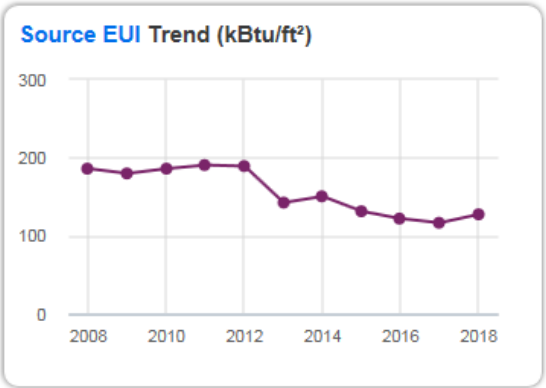


Figure 7-6. Hourly electric data – 230 E 9th (2016)

230 East 9th - Energy Star Review



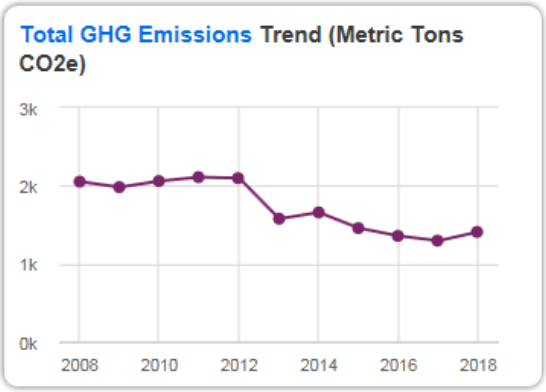


Figure 7-7. 230 E. 9th - EUI and GHG

Energy Star Score (1-100):

Current Score – 75
Baseline Score – 48
This building qualified 2013-2018.

Energy Star Charts:

The EPA's Energy Star website tracks the annual Energy Use Index (EUI) and Greenhouse Gas (GHG) emissions for a building based on the electricity, natural gas, and water usage.

The continued downward trends in both Source EUI and GHG emissions indicate the success of the energy conservation projects.

Energy Star Metrics:

This building has qualified for Energy Star for several years now. Table 7-1 shows that the ECMs have successfully reduced EUI, cost, and GHG emissions compared to the baseline year.

Table 7-1. Energy Star metrics summary – 230 E 9th

Metric	Energy Baseline (Jan 2007)	Energy Current (Nov 2018)	Change
ENERGY STAR score (1-100)	48	75	27.00 (56.20%)
Source EUI (kBtu/ft^2)	187.9	126.9	-61.00 (-32.50%)
Site EUI (kBtu/ft^2)	94.4	63.9	-30.50 (-32.30%)
Energy Cost ($)	358,859.70	205,653.37	-153206.33 (-42.70%)
Total GHG Emissions (Metric Tons CO2e)	10.8	7.3	-3.50 (-32.40%)
Water Use (All Water Sources) (kgal)	Not Available	2,046.6	N/A

250 William Howard Taft



Bldg Code:	0250
Address :	250 William Howard Taft Rd
City :	CINCINNATI
State :	OH
Postal Code:	45219
Site Code :	COUNTYCAMPUS
Agency :	HCGHD
Use :	Office
Const Type:	Stone
Date Built :	1964
Ext Gross Area:	51,851.06 sf
Int Gross Area:	48,738.40 sf
Rentable Area:	40,078.18 sf
Estimated Area:	0.00 sf
Total Roof Area:	16,654.72 sf
Leased/Owned :	Owned
Floor Count :	4
Sprinklered? :	Yes
Property :	092-0001-0048-00

Fl Code	Int Gross	Ext Gross	Vert Pen	Service	Rentable	Usable	Room Area
01	16,186 sf	17,939 sf	797 sf	3,724 sf	15,389 sf	11,664 sf	16,186 sf
02	16,050 sf	16,629 sf	297 sf	1,914 sf	15,753 sf	13,839 sf	16,050 sf
0B	16,502 sf	17,282 sf	7,566 sf	4,511 sf	8,936 sf	4,425 sf	16,502 sf
0R	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
OUT	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf

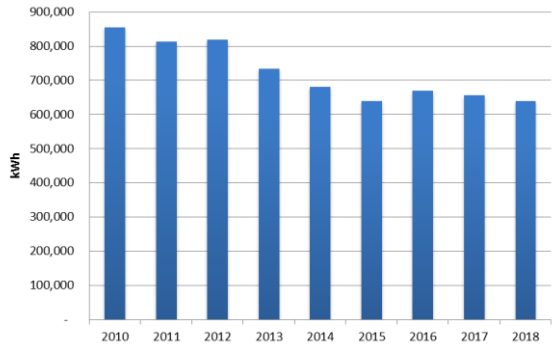


Figure 7-8. 250 WHT - annual electric usage

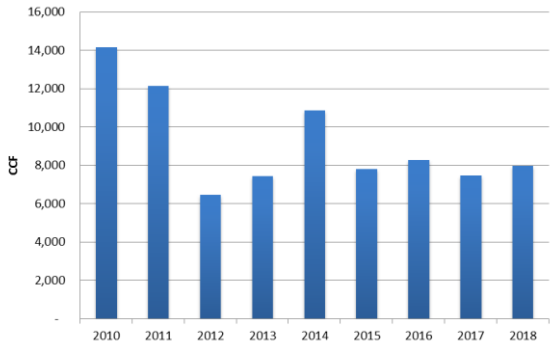


Figure 7-9. 250 WHT - annual gas usage

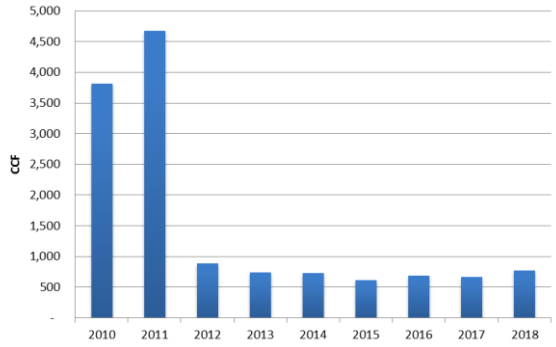


Figure 7-10. 250 WHT - annual water usage

Electric – lowest usage since 2010

Natural Gas – slight increase over previous year

Water – increase over previous year

250 William Howard Taft - Hourly Demand Review

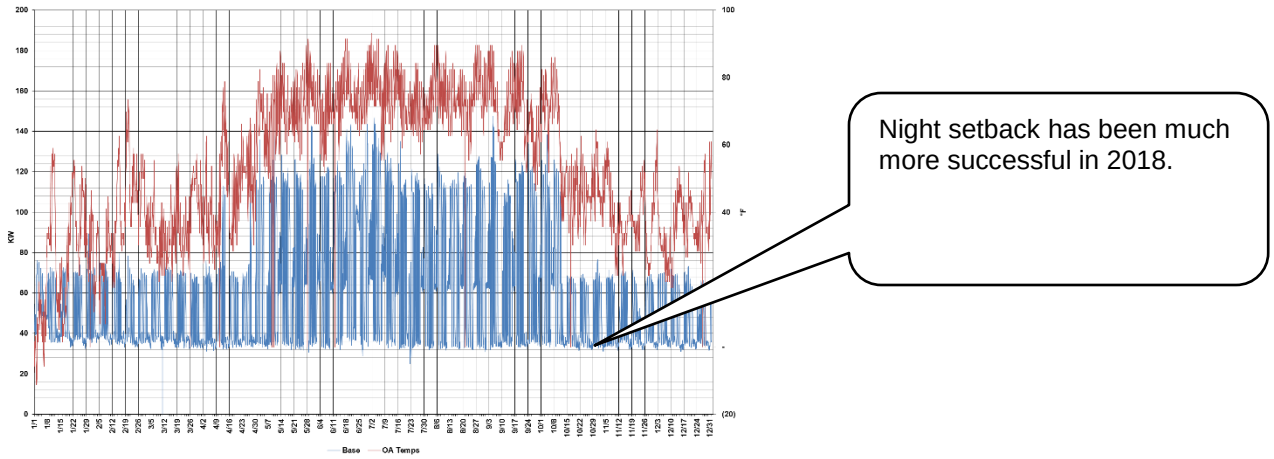


Figure 7-11. Hourly electric data – 250 WHT (2018)

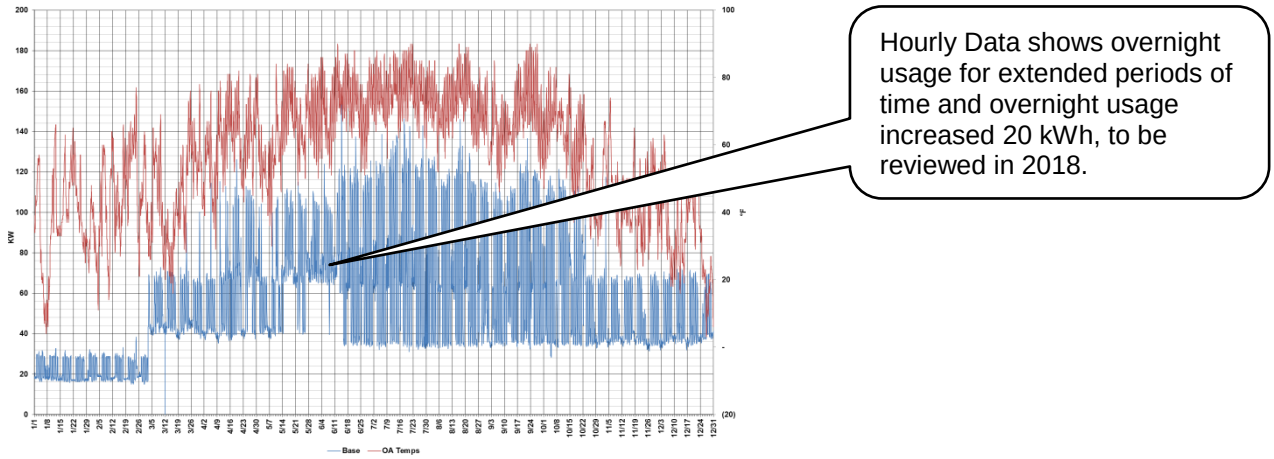


Figure 7-12. Hourly electric data – 250 WHT (2017)

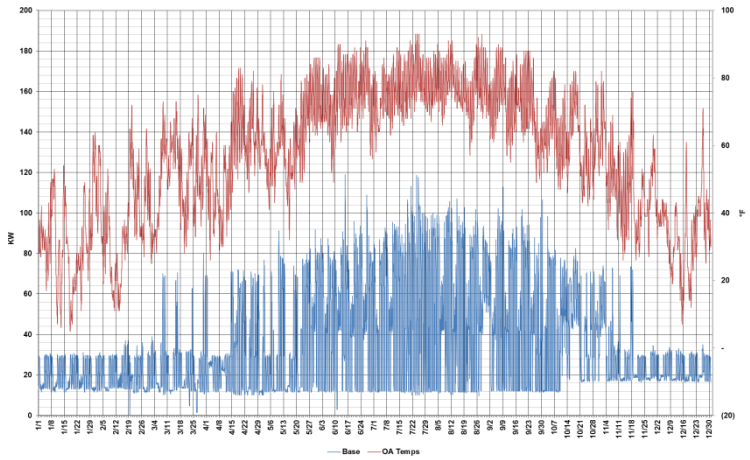


Figure 7-13. Hourly electric data – 250 WHT (2016)

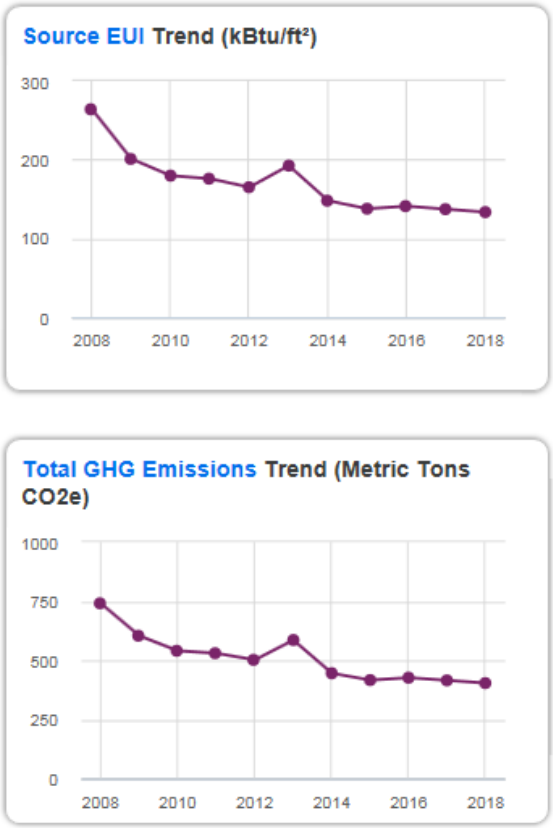


Figure 7-14. 250 WHT - EUI and GHG

Energy Star Score (1-100):

Current Score – 62
Baseline Score – 39
This building has been gradually improving, qualifying for an Energy Star rating in 2018.

Energy Star Charts:

The EPA's Energy Star website tracks the annual Energy Use Index (EUI) and Greenhouse Gas (GHG) emissions for a building based on the electricity, natural gas, and water usage.

The continued downward trends in both Source EUI and GHG emissions indicate the success of the energy conservation projects.

Energy Star Metrics:

This building is performing well. Table 7-2 shows that the ECMs have successfully reduced EUI and GHG emissions compared to the baseline year.

Table 7-2. Energy Star metrics summary – 250 WHT

Metric	Energy Baseline (Dec 2010)	Energy Current (Nov 2018)	Change
ENERGY STAR score (1-100)	39	62	23.00 (59.00%)
Source EUI (kBtu/ft^2)	179.8	134.0	-45.80 (-25.50%)
Site EUI (kBtu/ft^2)	81.7	587.6	-24.10 (-29.50%)
Energy Cost ($)	91,680.72	Not Available	N/A
Total GHG Emissions (Metric Tons CO2e)	10.4	7.8	-2.60 (-25.00%)
Water Use (All Water Sources) (kgal)	Not Available	573.7	N/A

800 Broadway Building



Bldg Code:	0800
Address :	800 Broadway Street
City :	CINCINNATI
State :	OH
Postal Code:	45202
Site Code :	COUNTYCAMPUS
Agency :	HC ADMIN
Use :	Office
Const Type:	Stone
Date Built :	1931
Ext Gross Area:	372,426.41 sf
Int Gross Area:	349,133.22 sf
Rentable Area:	295,319.29 sf
Estimated Area:	0.00 sf
Total Roof Area:	41,856.63 sf
Leased/Owned :	Owned
Floor Count :	19
Sprinklered? :	Yes
Property :	079-0003-0146-00

FI Code	Int Gross	Ext Gross	Vert Pen	Service	Rentable	Usable	Room Area
01	35,947 sf	38,116 sf	2,107 sf	7,399 sf	33,839 sf	26,440 sf	35,945 sf
02	35,943 sf	38,208 sf	2,794 sf	3,877 sf	33,149 sf	29,272 sf	35,943 sf
03	36,159 sf	38,196 sf	6,056 sf	5,417 sf	30,103 sf	24,686 sf	36,159 sf
03M	35,962 sf	38,076 sf	19,439 sf	9,520 sf	16,523 sf	7,003 sf	36,049 sf
04	31,920 sf	33,764 sf	1,386 sf	3,012 sf	30,534 sf	27,521 sf	31,920 sf
05	21,001 sf	22,426 sf	4,848 sf	1,667 sf	16,153 sf	14,487 sf	21,053 sf
06	20,213 sf	21,652 sf	1,248 sf	4,369 sf	18,965 sf	14,596 sf	20,203 sf
07	5,674 sf	6,191 sf	553 sf	763 sf	5,121 sf	4,358 sf	5,602 sf
08	5,671 sf	6,191 sf	754 sf	1,220 sf	4,917 sf	3,696 sf	5,671 sf
09	5,749 sf	6,190 sf	750 sf	1,247 sf	4,999 sf	3,752 sf	5,749 sf
0B	39,778 sf	41,890 sf	7,997 sf	10,776 sf	31,781 sf	21,004 sf	39,778 sf
0R	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
10	5,683 sf	6,191 sf	730 sf	1,275 sf	4,954 sf	3,678 sf	5,683 sf
11	5,703 sf	6,191 sf	771 sf	1,307 sf	4,933 sf	3,625 sf	5,704 sf
12	5,035 sf	5,541 sf	766 sf	1,146 sf	4,269 sf	3,123 sf	5,014 sf
14	5,133 sf	5,541 sf	764 sf	1,117 sf	4,369 sf	3,252 sf	5,133 sf
15	4,392 sf	4,851 sf	761 sf	856 sf	3,631 sf	2,776 sf	4,392 sf
16	3,751 sf	4,151 sf	748 sf	1,276 sf	3,003 sf	1,727 sf	3,751 sf
17	3,655 sf	4,193 sf	473 sf	3,182 sf	3,182 sf	0 sf	3,655 sf
18	2,980 sf	3,294 sf	91 sf	2,889 sf	2,889 sf	-0 sf	2,980 sf
OUT	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
SB	38,785 sf	41,572 sf	779 sf	11,109 sf	38,006 sf	26,897 sf	38,785 sf

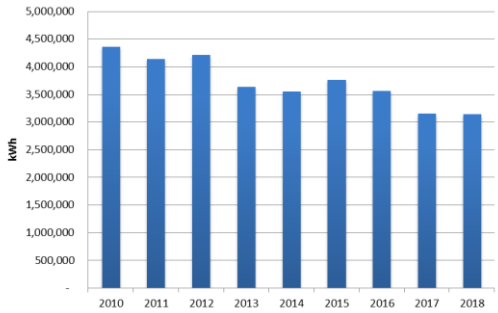


Figure 7-15. 800 Broadway - annual electric usage

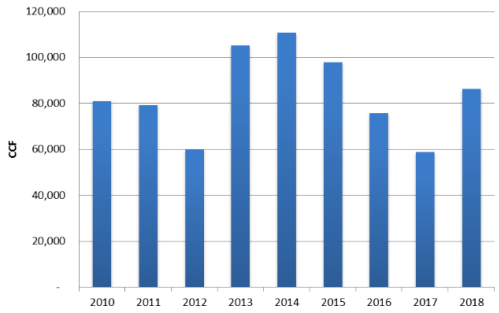


Figure 7-16. 800 Broadway - annual gas usage

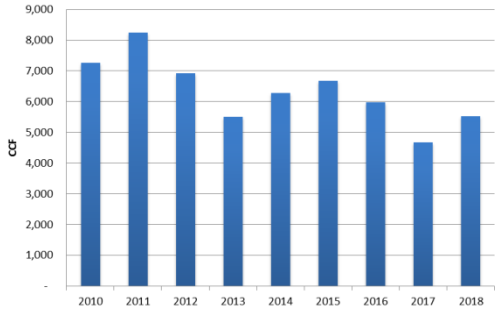


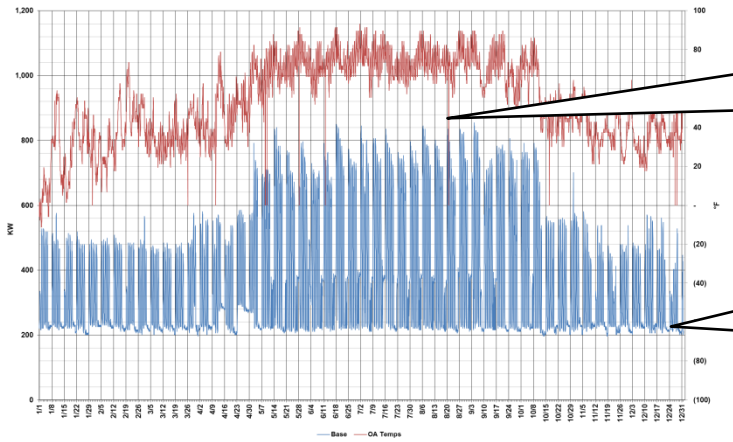
Figure 7-17. 800 Broadway - annual water usage

Electric – continued decrease since 2015 and overall ten-year downward trend

Natural Gas – significant increase over previous two years

Water – increase over previous year but otherwise low of last several years

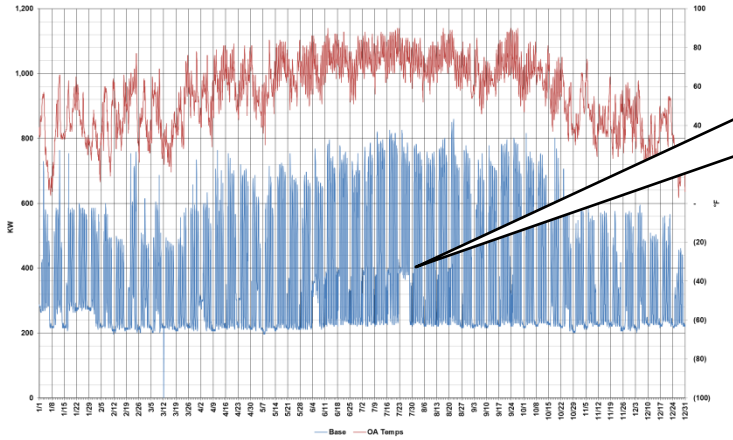
800 Broadway Building - Hourly Demand Review



Peak demand has increased in the summer, with higher power consumption at the beginning of the week.

Night setback continues to be utilized effectively.

Figure 7-18. Hourly electric data – 800 Broadway (2018)



2017 Hourly Data shows overnight usage is down significantly and overnight peaks virtually eliminated!

Figure 7-19. Hourly electric data – 800 Broadway (2017)

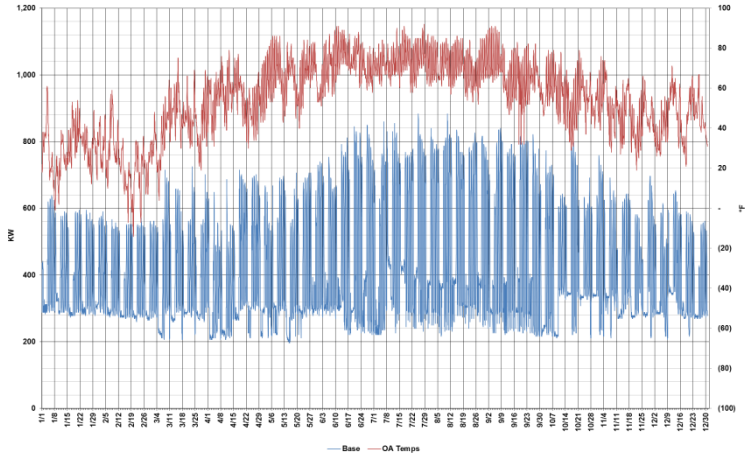
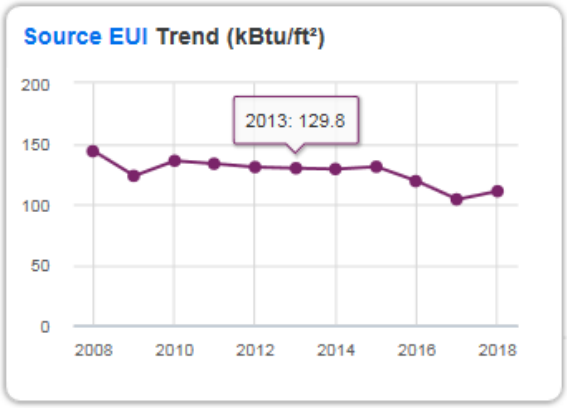


Figure 7-20. Hourly electric data – 800 Broadway (2016)

800 Broadway Building - Energy Star Review



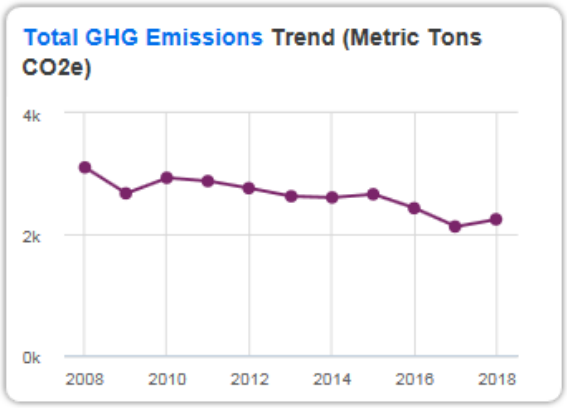


Figure 7-21. 800 Broadway - EUI and GHG

Energy Star Score (1-100):

Current Score – 74
Baseline Score – 63
This building qualified 2008-2018. This building also received the LEED EB+OM certification in 2014.

Energy Star Charts:

The EPA's Energy Star website tracks the Energy Use Index (EUI) and the Greenhouse Gas (GHG) emissions annually for a building based on the electricity, natural gas and water usage.

The EUI and GHG emissions showed marked improvement in 2016 after remaining fairly constant since 2011, with both showing overall downward trends.

Energy Star Metrics:

Table 7-3 shows that the ECMs have successfully reduced EUI, cost, and GHG emissions compared to the baseline year. This building continues to receive good marks in the Energy Star score.

Table 7-3. Energy Star metrics summary – 800 Broadway

Metric	Energy Baseline (Dec 2007)	Energy Current (Nov 2018)	Change
ENERGY STAR score (1-100)	63	74	11.00 (17.50%)
Source EUI (kBtu/ft^2)	131.0	111.1	-19.90 (-15.20%)
Site EUI (kBtu/ft^2)	64.3	55.0	-9.30 (-14.50%)
Energy Cost ($)	295,660.97	269,933.22	-25727.75 (-8.70%)
Total GHG Emissions (Metric Tons CO2e)	7.5	6.4	-1.10 (-14.70%)
Water Use (All Water Sources) (kgal)	5,143.1	4,129.5	-1013.60 (-19.70%)

County Administration Building



Bldg Code:	0138
Address :	138 East Court Street
City :	CINCINNATI
State :	OH
Postal Code:	45202
Site Code :	COUNTYCAMPUS
Agency :	HC ADMIN
Use :	Office
Const Type:	BrickStone
Date Built :	1987
Ext Gross Area:	209,063.35 sf
Int Gross Area:	196,731.47 sf
Rentable Area:	182,707.46 sf
Estimated Area:	0.00 sf
Total Roof Area:	20,488.00 sf
Leased/Owned :	Owned
Floor Count :	11
Sprinklered? :	Yes
Property :	079-0001-0128-90

Fl Code	Int Gross	Ext Gross	Vert Pen	Service	Rentable	Usable	Room Area
01	16,844 sf	17,852 sf	2,008 sf	4,933 sf	14,836 sf	9,902 sf	16,844 sf
02	18,023 sf	19,162 sf	2,071 sf	2,581 sf	15,952 sf	13,371 sf	18,023 sf
03	17,934 sf	19,039 sf	1,567 sf	2,876 sf	16,367 sf	13,491 sf	18,191 sf
04	17,929 sf	19,030 sf	1,559 sf	2,864 sf	16,371 sf	13,507 sf	18,142 sf
05	17,419 sf	18,552 sf	899 sf	2,601 sf	16,520 sf	13,919 sf	17,419 sf
06	17,414 sf	18,553 sf	930 sf	3,078 sf	16,485 sf	13,407 sf	17,411 sf
07	17,407 sf	18,549 sf	902 sf	2,574 sf	16,505 sf	13,932 sf	17,407 sf
08	17,400 sf	18,553 sf	892 sf	2,991 sf	16,508 sf	13,517 sf	17,400 sf
09	17,400 sf	18,553 sf	862 sf	3,165 sf	16,538 sf	13,374 sf	17,398 sf
0B	21,521 sf	22,616 sf	1,432 sf	10,138 sf	20,089 sf	9,951 sf	21,521 sf
0R	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
10	17,440 sf	18,606 sf	902 sf	3,507 sf	16,538 sf	13,032 sf	17,373 sf
OUT	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf

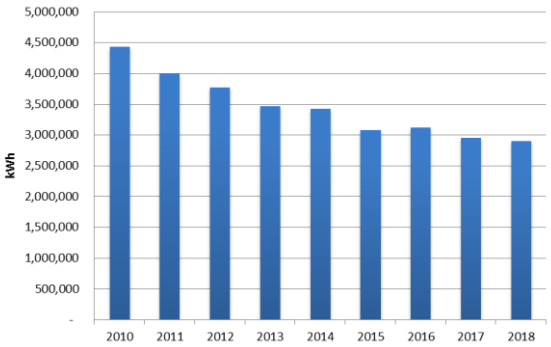


Figure 7-22. Administration - annual electric usage

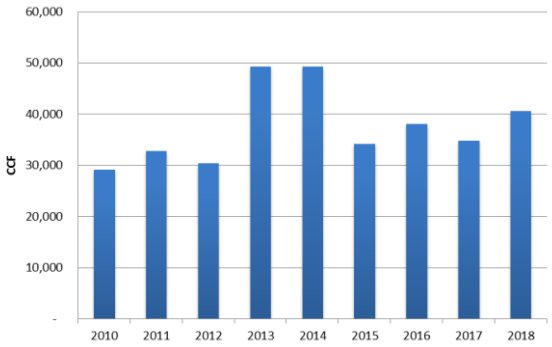


Figure 7-23. Administration - annual gas usage

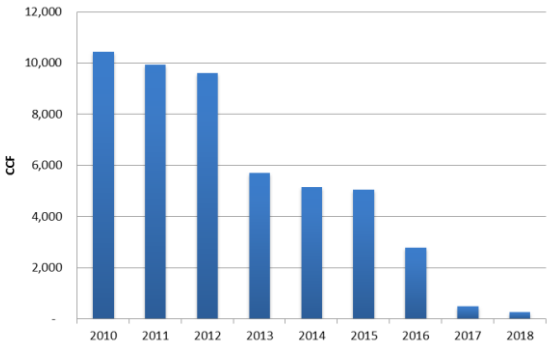


Figure 7-24. Administration - annual water usage

Electric – continued overall downward trend with new ten-year low

Natural Gas – increase over last few years

Water – significant water reduction compared to previous years continues.

County Administration Building - Hourly Demand Review

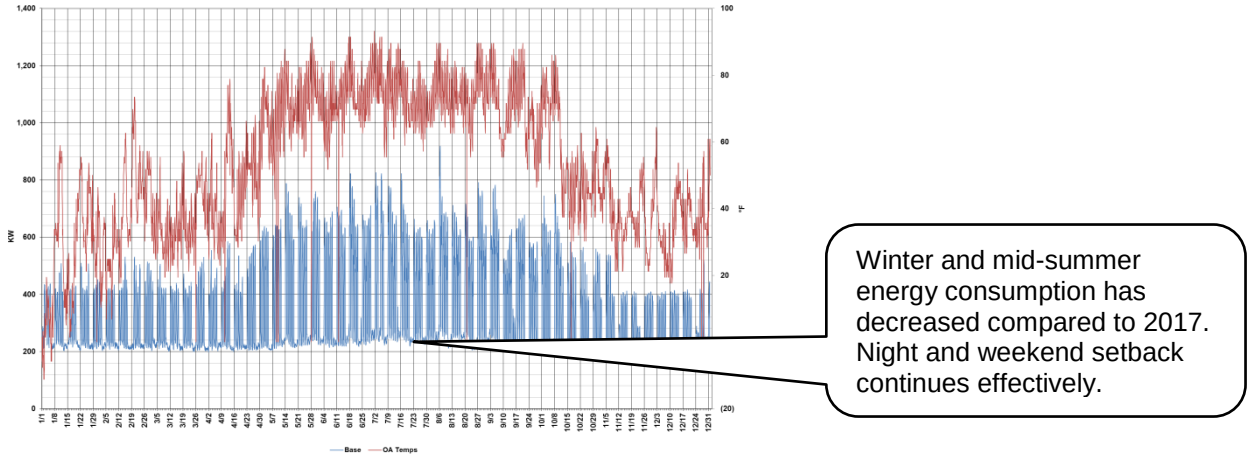


Figure 7-25. Hourly electric data – Administration (2018)

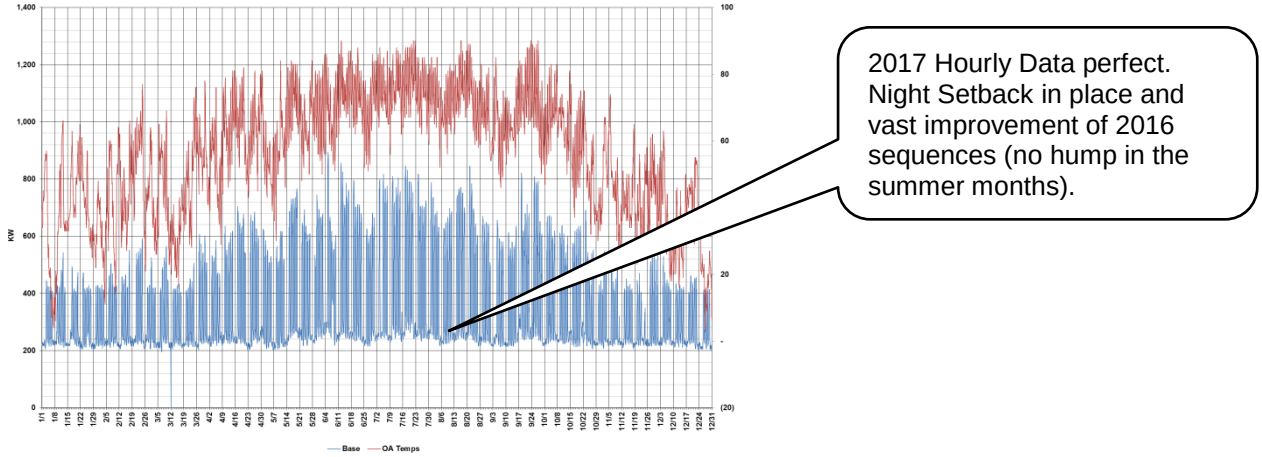


Figure 7-26. Hourly electric data – Administration (2017)

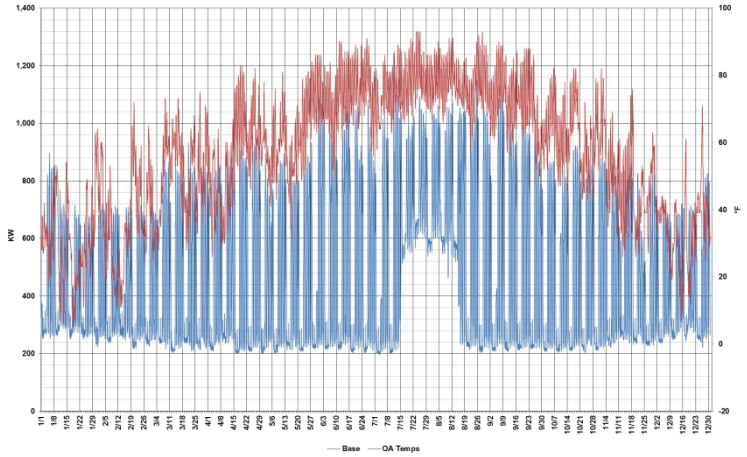


Figure 7-27. Hourly electric data – Administration (2016)

County Administration Building - Energy Star Review

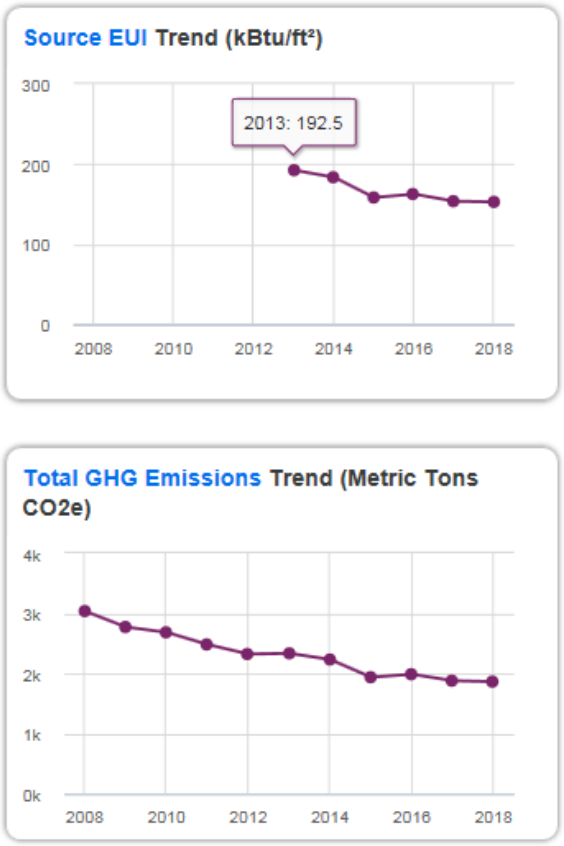


Figure 7-28. Admin - EUI and GHG

Energy Star Score (1-100):

Current Score – 69
Baseline Score – 61
This building qualified for Energy Star nearly every year from 2012 through 2018.

Energy Star Charts:

The EPA's Energy Star website tracks the Energy Use Index (EUI) and the Greenhouse Gas (GHG) emissions annually for a building based on the electricity, natural gas and water usage.

The general downward source EUI and GHG emissions trend continued.

Energy Star Metrics:

This building has qualified for Energy Star for several years now until the Energy Star metric update. Table 7-4 shows that the ECMs have successfully reduced EUI, cost, GHG emissions, and water use compared to the baseline year.

Table 7-4. Energy Star metrics summary – Administration

Metric	Energy Baseline (Dec 2014)	Energy Current (Nov 2018)	Change
ENERGY STAR score (1-100)	61	69	8.00 (13.10%)
Source EUI (kBtu/ft^2)	183.7	153.4	-30.30 (-16.50%)
Site EUI (kBtu/ft^2)	82.4	67.1	-15.30 (-18.60%)
Energy Cost ($)	336,479.24	259,523.34	-15.30 (-18.60%)
Total GHG Emissions (Metric Tons CO2e)	10.7	8.9	-1.80 (-16.80%)
Water Use (All Water Sources) (kgal)	3,819.1	198.7	-3620.40 (-94.80%)

Alms & Doepke (Jobs & Family Services)



Bldg Code:	0222
Address :	222 East Central Parkway
City :	CINCINNATI
State :	OH
Postal Code:	45202
Site Code :	COUNTYCAMPUS
Agency :	HCJFS
Use :	Office
Const Type:	Brick
Date Built :	1878
Ext Gross Area:	302,820.15 sf
Int Gross Area:	283,130.16 sf
Rentable Area:	257,525.42 sf
Estimated Area:	0.00 sf
Total Roof Area:	0.00 sf
Leased/Owned :	Owned
Floor Count :	8
Sprinklered? :	Yes
Property :	075-0004-0240-00

Fl Code	Int Gross	Ext Gross	Vert Pen	Service	Rentable	Usable	Room Area
01	38,038 sf	39,989 sf	1,439 sf	8,646 sf	36,599 sf	27,953 sf	38,038 sf
02	37,707 sf	40,218 sf	1,467 sf	5,032 sf	36,240 sf	31,208 sf	37,707 sf
03	37,766 sf	40,236 sf	1,406 sf	4,363 sf	36,360 sf	31,997 sf	37,722 sf
04	37,835 sf	40,218 sf	1,457 sf	4,188 sf	36,378 sf	32,190 sf	37,554 sf
05	37,981 sf	40,932 sf	1,355 sf	5,035 sf	36,626 sf	31,590 sf	37,249 sf
06	29,458 sf	31,598 sf	1,695 sf	4,075 sf	27,763 sf	23,689 sf	29,073 sf
07	4,950 sf	5,460 sf	376 sf	475 sf	4,574 sf	4,099 sf	4,950 sf
0B	37,348 sf	40,552 sf	1,372 sf	7,843 sf	35,976 sf	28,133 sf	37,348 sf
OUT	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
SB	22,047 sf	23,617 sf	15,037 sf	845 sf	7,010 sf	6,165 sf	22,047 sf

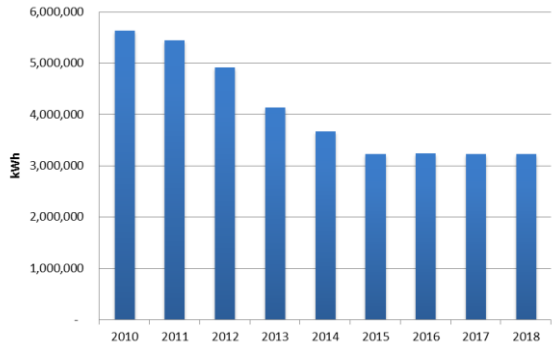


Figure 7-29. A&D - annual electric usage

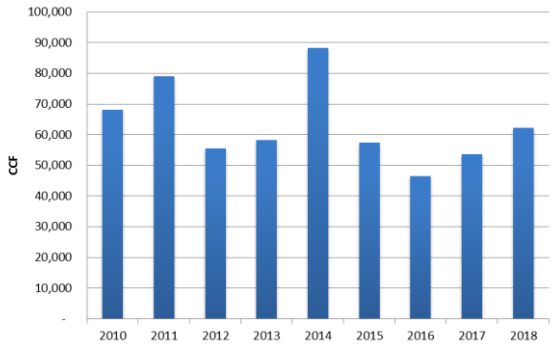


Figure 7-30. A&D - annual gas usage

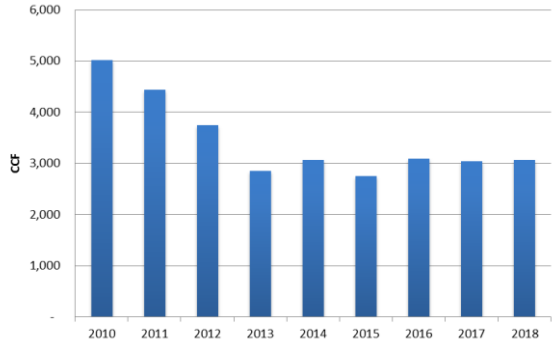


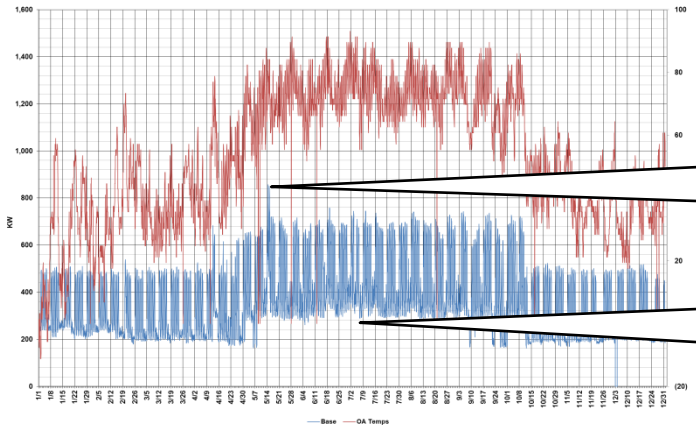
Figure 7-31. A&D - annual water usage

Electric – remained steady last couple years

Natural Gas – steady increase in usage last three years

Water – remained steady, holding decrease since ECM project began in 2009.

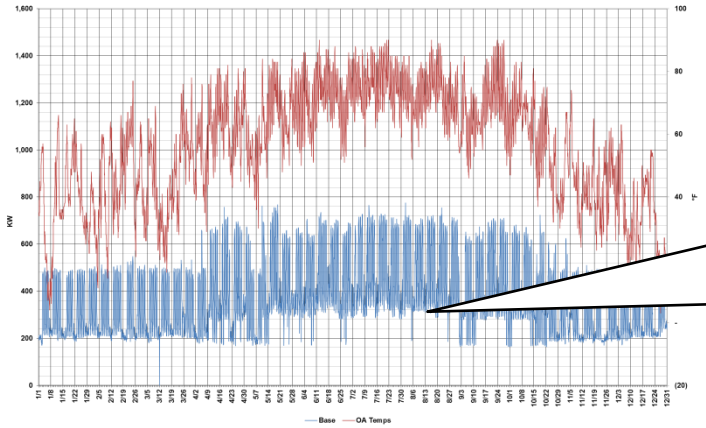
Alms & Doepke (Jobs & Family Services) - Hourly Demand Review



The 2018 profile remains very similar to 2017. The peak upon startup of the cooling equipment for the year is high.

Night Setback no fully realized at this building indicated by this energy use overnight and weekends during summer.

Figure 7-32. Hourly electric data – A&D (2018)



2017 Hourly Data shows that this building does keep chillers and air handlers on overnight and has for three straight years. Consider scheduling chillers off overnight by using night setback and reclaim some electric kwh savings.

Figure 7-33. Hourly electric data – A&D (2017)

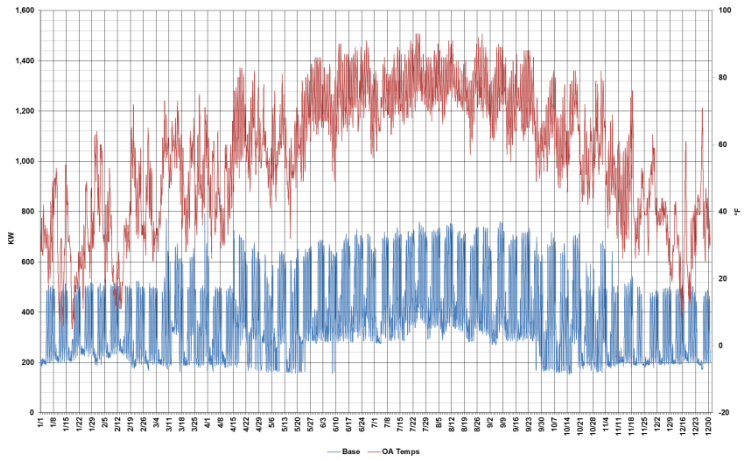
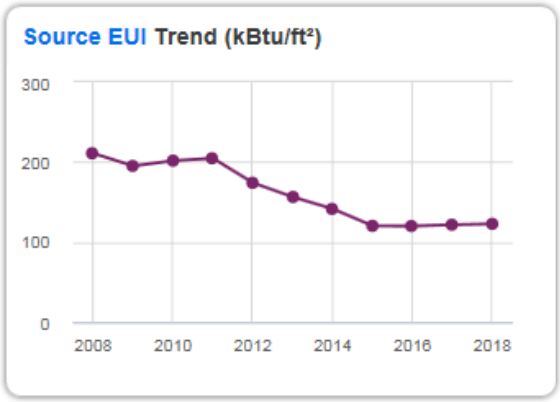


Figure 7-34. Hourly electric data – A&D (2016)

Alms & Doepke (Jobs & Family Services) - Energy Star Review



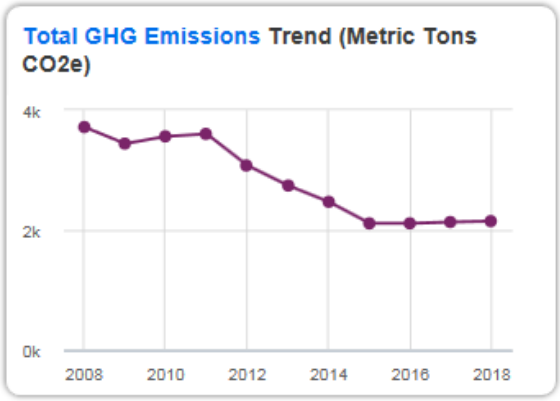


Figure 7-35. A&D - EUI and GHG

Energy Star Score (1-100):

Current Score – 75
Baseline Score – 30
This building qualified for Energy Star Certification from 2015-2018.

Energy Star Charts:

The EPA's Energy Star website tracks the Energy Use Index (EUI) and the Greenhouse Gas (GHG) emissions annually for a building based on the electricity, natural gas and water usage.

The overall downward trends in EUI and GHG emissions indicate the success of the energy conservation projects.

Energy Star Metrics:

This building has qualified for Energy Star for several years now. Table 7-5 shows that the ECMs have successfully reduced EUI, cost, and GHG emissions compared to the baseline year.

Table 7-5. Energy Star metrics summary – A&D

Metric	Energy Baseline (Jan 2010)	Energy Current (Nov 2018)	Change
ENERGY STAR score (1-100)	30	75	45.00 (150.00%)
Source EUI (kBtu/ft^2)	193.0	123.4	-69.60 (-36.10%)
Site EUI (kBtu/ft^2)	83.9	57.1	-26.80 (-31.90%)
Energy Cost ($)	496,420.57	274,643.52	-221777.05 (-44.70%)
Total GHG Emissions (Metric Tons CO2e)	11.2	7.1	-4.10 (-36.60%)
Water Use (All Water Sources) (kgal)	Not Available	2,621.2	N/A

Hamilton County Courthouse



Bldg Code:	1000
Address :	1000 Main Street
City :	CINCINNATI
State :	OH
Postal Code:	45202
Site Code :	COUNTYCAMPUS
Agency :	HC ADMIN
Use :	Office
Const Type:	Stone
Date Built :	1915
Ext Gross Area:	553,685.02 sf
Int Gross Area:	516,485.91 sf
Rentable Area:	398,441.17 sf
Estimated Area:	0.00 sf
Total Roof Area:	77,077.67 sf
Leased/Owned :	Owned
Floor Count :	9
Sprinklered? :	Yes
Property :	079-0002-0017-90

Fl Code	Int Gross	Ext Gross	Vert Pen	Service	Rentable	Usable	Room Area
01	69,885 sf	73,992 sf	12,388 sf	21,316 sf	57,497 sf	36,181 sf	69,885 sf
02	69,717 sf	74,373 sf	19,912 sf	17,934 sf	49,805 sf	31,870 sf	69,717 sf
03	68,305 sf	75,498 sf	12,721 sf	15,910 sf	55,583 sf	39,673 sf	68,305 sf
04	68,306 sf	73,426 sf	24,512 sf	18,123 sf	43,794 sf	25,671 sf	68,306 sf
05	68,235 sf	73,420 sf	13,197 sf	18,851 sf	55,038 sf	36,187 sf	68,236 sf
06	70,734 sf	73,464 sf	23,067 sf	12,579 sf	47,667 sf	35,088 sf	70,734 sf
07	24,384 sf	26,699 sf	7,335 sf	2,988 sf	17,049 sf	14,061 sf	24,384 sf
0B	70,255 sf	75,493 sf	2,817 sf	26,496 sf	67,438 sf	40,942 sf	70,255 sf
0R	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
OUT	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
SB	6,665 sf	7,319 sf	2,095 sf	4,300 sf	4,570 sf	270 sf	6,665 sf

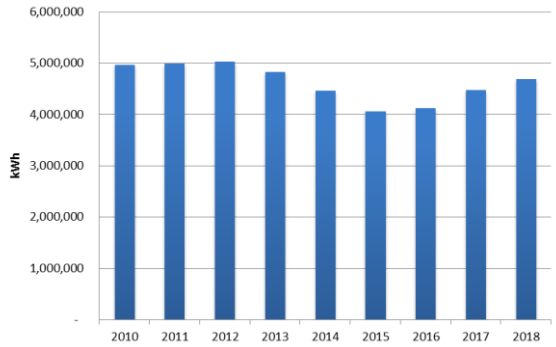


Figure 7-36. Courthouse - annual electric usage

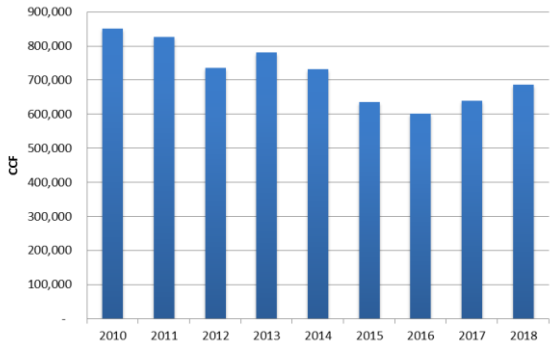


Figure 7-37. Courthouse - annual gas usage

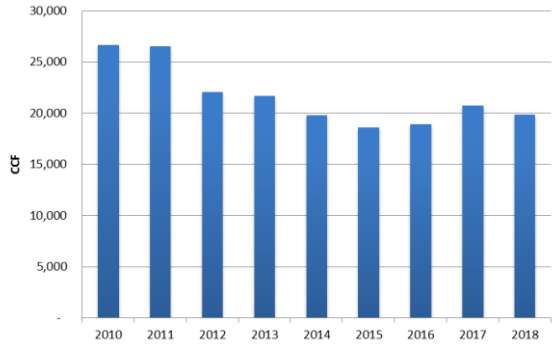


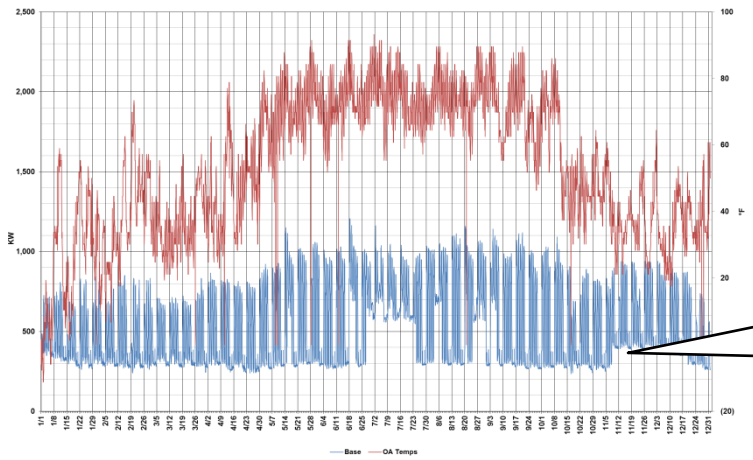
Figure 7-38. Courthouse - annual water usage

Electric – continued increase since 2015

Natural Gas – slight increase from 2016, though still lower than pre-2015 levels

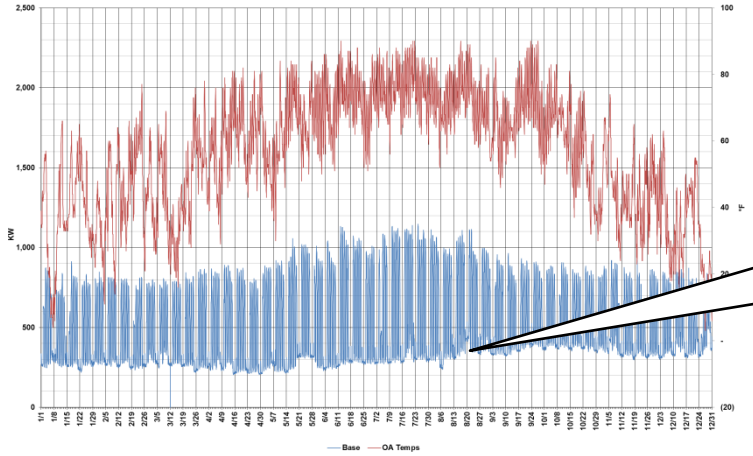
Water – slight decrease from previous year

Hamilton County Courthouse - Hourly Demand Review



Wintertime power decreased compared to 2017. Overnight usage began again throughout the summer, and toward the end of the year.

Figure 7-39. Hourly electric data – Courthouse (2018)



2017 Hourly Data shows this building did a great job of removing overnight usage through the summer!

Figure 7-40. Hourly electric data – Courthouse (2017)

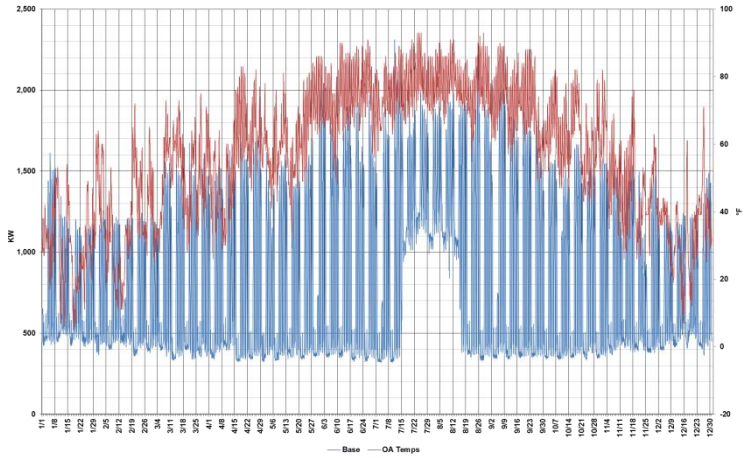
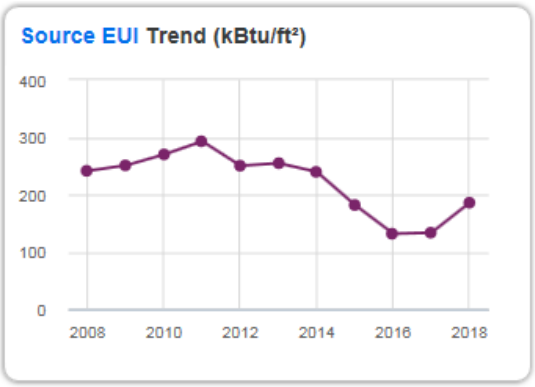


Figure 7-41. Hourly electric data – Courthouse (2016)



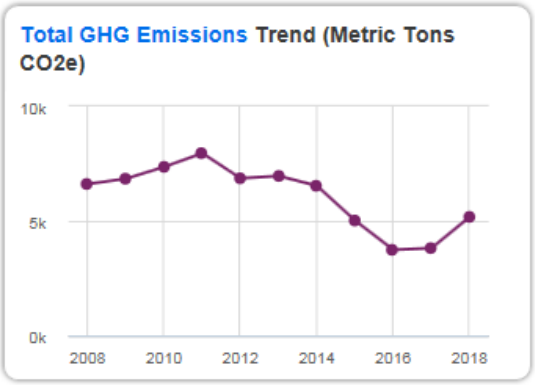


Figure 7-42. Courthouse - EUI and GHG

Energy Star Score (1-100):

Current Score – 37
Baseline Score – 7
Additional metering was installed in 2015 to better calculate the Energy Star score. This building qualified for Energy Star in 2017 & 2018.

Energy Star Charts:

The EPA's Energy Star website tracks the annual Energy Use Index (EUI) and the Greenhouse Gas (GHG) emissions for a building based on the electricity, natural gas and water usage. New metering is greatly improved the Courthouse scores in 2016.

The continued downward trends in both Source EUI and GHG emissions since 2011 indicate the success of the energy conservation projects.

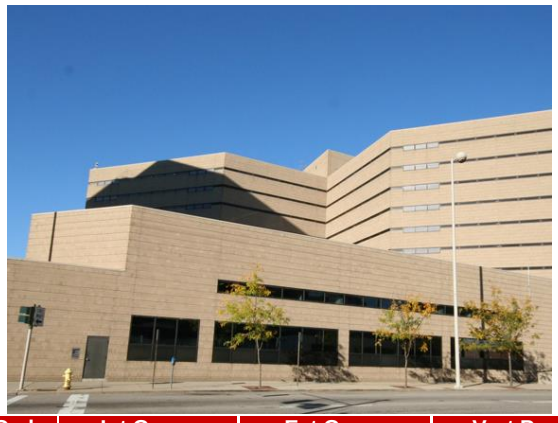
Energy Star Metrics:

The Metrics at the Courthouse have improved at a steady pace, partially because of better accounting and measurement of the Courthouse supplying steam to the Justice Center. Table 7-6 shows that the ECMs have successfully reduced EUI, cost, and GHG emissions compared to the baseline year.

Table 7-6. Energy Star metrics summary – Courthouse

Metric	Energy Baseline (Dec 2006)	Energy Current (Nov 2018)	Change
ENERGY STAR score (1-100)	7	37	30.00 (428.60%)
Source EUI (kBtu/ft^2)	286.8	172.9	-113.90 (-39.70%)
Site EUI (kBtu/ft^2)	211.9	112.5	-99.40 (-46.90%)
Energy Cost ($)	1,159,597.41	462,929.53	-696667.88 (-60.10%)
Total GHG Emissions (Metric Tons CO2e)	15.4	9.5	-5.90 (-38.30%)
Water Use (All Water Sources) (kgal)	Not Available	15,126.8	N/A

Hamilton County Justice Center



Bldg Code:	1100
Address :	1000 Sycamore Street
City :	CINCINNATI
State :	OH
Postal Code:	45202
Site Code :	COUNTYCAMPUS
Agency :	HC SHERIFF
Use :	Jail
Const Type:	Masonry
Date Built :	1985
Ext Gross Area:	736,872.25 sf
Int Gross Area:	722,744.49 sf
Rentable Area:	490,446.36 sf
Estimated Area:	0.00 sf
Total Roof Area:	95,778.18 sf
Leased/Owned :	Owned
Floor Count :	26
Sprinklered? :	Yes
Property :	075-0001-0147-90

FI Code	Int Gross	Ext Gross	Vert Pen	Service	Rentable	Usable	Room Area
N01	33,634 sf	34,489 sf	1,916 sf	8,075 sf	31,719 sf	23,644 sf	33,634 sf
N01M	33,971 sf	35,007 sf	14,246 sf	7,810 sf	19,725 sf	11,915 sf	33,971 sf
N02	31,926 sf	32,831 sf	2,347 sf	3,887 sf	29,579 sf	25,692 sf	31,926 sf
N02M	31,901 sf	32,810 sf	25,699 sf	46 sf	6,201 sf	6,156 sf	31,901 sf
N03	32,256 sf	32,676 sf	2,678 sf	378 sf	29,578 sf	29,200 sf	32,289 sf
N03M	32,365 sf	32,673 sf	20,337 sf	43 sf	12,028 sf	11,985 sf	32,473 sf
N04	32,166 sf	32,606 sf	2,680 sf	367 sf	29,486 sf	29,119 sf	32,250 sf
N04M	32,302 sf	32,605 sf	14,472 sf	43 sf	17,829 sf	17,787 sf	32,376 sf
N05	32,070 sf	32,673 sf	2,317 sf	351 sf	29,752 sf	29,401 sf	32,071 sf
N05M	32,072 sf	32,673 sf	20,479 sf	43 sf	11,593 sf	11,550 sf	32,071 sf
N0B	21,707 sf	22,489 sf	994 sf	14,568 sf	20,713 sf	6,145 sf	21,707 sf
N0P	1,851 sf	2,112 sf	351 sf	1,354 sf	1,500 sf	146 sf	1,851 sf
N0R	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
NSB	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
OUT	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
S01	55,187 sf	56,216 sf	2,334 sf	12,245 sf	52,853 sf	40,608 sf	55,183 sf
S01M	53,671 sf	55,123 sf	26,257 sf	13,465 sf	27,414 sf	13,949 sf	53,671 sf
S02	33,024 sf	33,320 sf	2,809 sf	338 sf	30,215 sf	29,877 sf	33,023 sf
S02M	32,385 sf	32,794 sf	21,586 sf	42 sf	10,799 sf	10,757 sf	32,385 sf
S03	32,376 sf	32,676 sf	2,651 sf	410 sf	29,724 sf	29,315 sf	32,376 sf
S03M	32,243 sf	32,675 sf	20,626 sf	44 sf	11,617 sf	11,572 sf	32,242 sf
S04	32,167 sf	32,606 sf	2,543 sf	352 sf	29,624 sf	29,272 sf	32,170 sf
S04M	32,249 sf	32,673 sf	20,633 sf	44 sf	11,617 sf	11,572 sf	32,249 sf
S05	32,133 sf	32,673 sf	2,195 sf	351 sf	29,937 sf	29,586 sf	32,134 sf
S05M	32,072 sf	32,673 sf	20,640 sf	44 sf	11,432 sf	11,388 sf	32,069 sf
S0B	5,168 sf	5,684 sf	1,158 sf	1,564 sf	4,010 sf	2,447 sf	5,168 sf
S0P	1,851 sf	2,112 sf	351 sf	1,500 sf	1,500 sf	0 sf	1,851 sf
S0R	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf

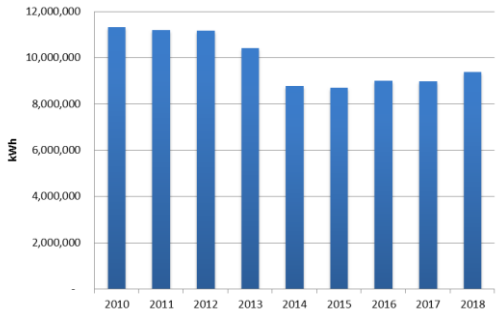


Figure 7-43. Justice Center - annual electric usage

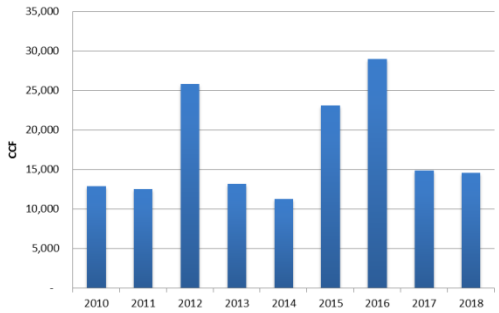


Figure 7-44. Justice Center - annual gas usage

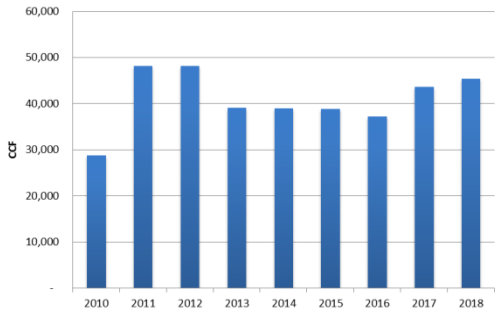
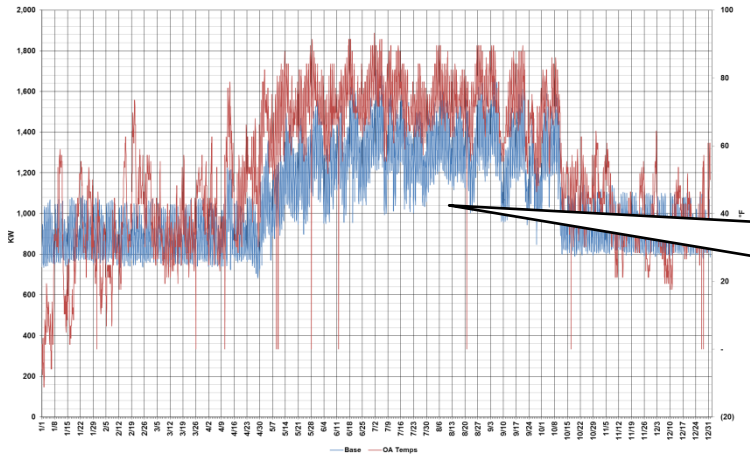


Figure 7-45. Justice Center - annual water usage

Electric – continued increase over last few years

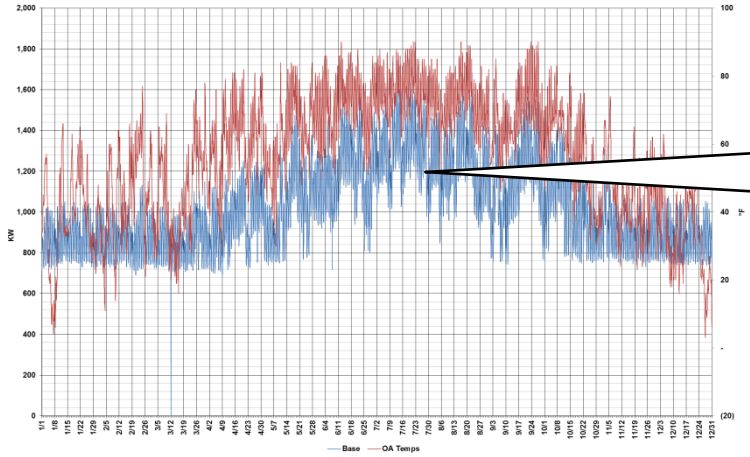
Natural Gas – gas usage continues to be low, with a slight decrease in use from 2016

Water – increased to pre-2013 levels



Day and night power consumption increased slightly. Justice Center does not use night setback.

Figure 7-46. Hourly electric data – Justice Center (2018)



2017 Hourly Data indicates this facility is a 24/7 operated facility with limited ability to reduce overnight usage and demand.

Figure 7-47. Hourly electric data – Justice Center (2017)

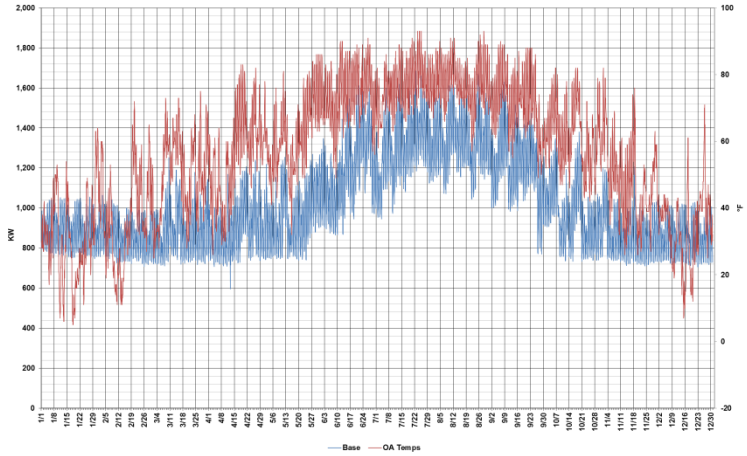


Figure 7-48. Hourly electric data – Justice Center (2016)

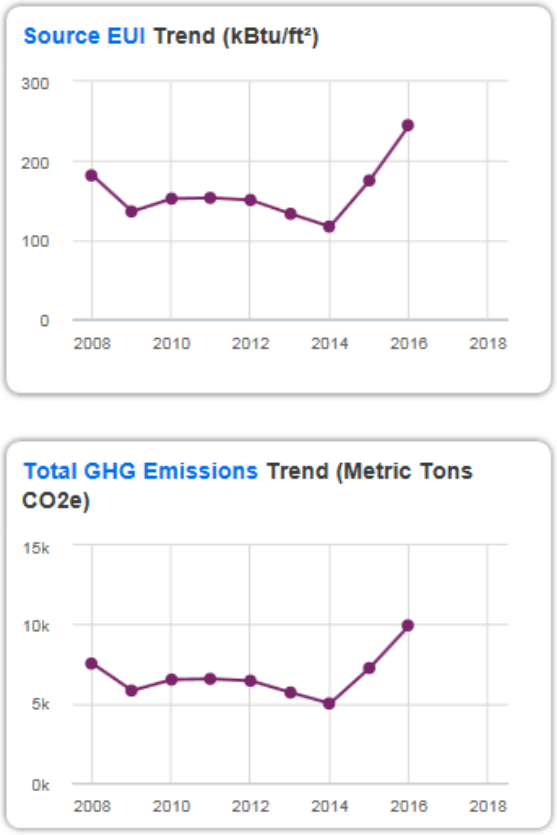


Figure 7-49. Justice Center - EUI and GHG

Energy Star Score (1-100):

Current Score – 32
Baseline Score – 45
The EUI and Energy Star have been adjusted to account for new metering installed at the Courthouse, as evidenced by the drastic change in 2016, to account for district heating provided by the Courthouse. The good news is that the Courthouse does now qualify for Energy Star. The Justice Center cannot qualify for certification because the Energy Star group has no certifications for jails.

Energy Star Charts:

The EPA's Energy Star website tracks the Energy Use Index (EUI) and the Greenhouse Gas (GHG) emissions annually for a building based on the electricity, natural gas and water usage.

Both EUI and GHG emissions have increased as expected as a result of district steam for the Courthouse now being recorded at the Justice Center

Energy Star Metrics:

The Metrics at the Justice Center have changed since the CH district steam plant was modeled in Energy Star. This will drive JC metrics back up.

Table 7-7. Energy Star metrics summary – Justice Center

Metric	Energy Baseline (Dec 2006)	Energy Current (Aug 2017)	Change
ENERGY STAR score (1-100)	45	32	-13.00 (-28.90%)
Source EUI (kBtu/ft^2)	219.6	258.7	39.10 (17.80%)
Site EUI (kBtu/ft^2)	116.8	165.7	48.90 (41.90%)
Energy Cost ($)	785,095.80	Not Available	N/A
Total GHG Emissions (Metric Tons CO2e)	12.5	14.5	2.00 (16.00%)
Water Use (All Water Sources) (kgal)	Not Available	31,535.4	N/A

Juvenile Detention Center (2020 Auburn)



Bldg Code:	2020
Address :	2020 Auburn Ave
City :	CINCINNATI
State :	OH
Postal Code:	45219
Site Code :	OTHER LOCATIONS
Agency :	HCJUVCT
Use :	Jail
Const Type:	ConcreteBrick
Date Built :	1995
Ext Gross Area:	171,450.02 sf
Int Gross Area:	164,410.36 sf
Rentable Area:	155,183.70 sf
Estimated Area:	0.00 sf
Total Roof Area:	40,319.30 sf
Leased/Owned :	Owned
Floor Count :	6
Sprinklered? :	Yes
Property :	088-0007-0020-90

Fl Code	Int Gross	Ext Gross	Vert Pen	Service	Rentable	Usable	Room Area
01	41,361 sf	42,828 sf	1,201 sf	12,926 sf	40,160 sf	27,234 sf	41,360 sf
02	29,514 sf	30,891 sf	1,323 sf	4,835 sf	28,191 sf	23,356 sf	29,514 sf
03	29,611 sf	30,891 sf	1,132 sf	4,466 sf	28,480 sf	24,014 sf	29,611 sf
04	19,237 sf	20,422 sf	1,132 sf	3,510 sf	18,105 sf	14,595 sf	19,237 sf
0B	3,179 sf	3,535 sf	0 sf	3,179 sf	3,179 sf	0 sf	3,179 sf
0R	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf	0 sf
LL	41,508 sf	42,884 sf	4,439 sf	19,862 sf	37,070 sf	17,208 sf	41,508 sf

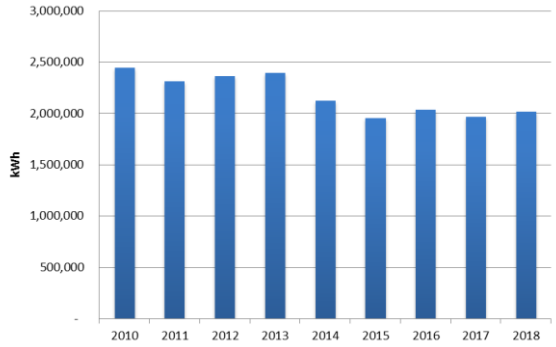


Figure 7-50. 2020 - annual electric usage

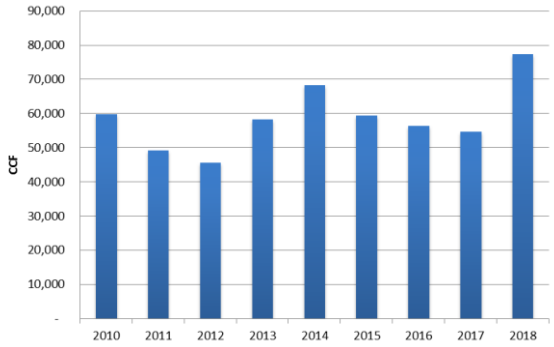


Figure 7-51. 2020 - annual gas usage

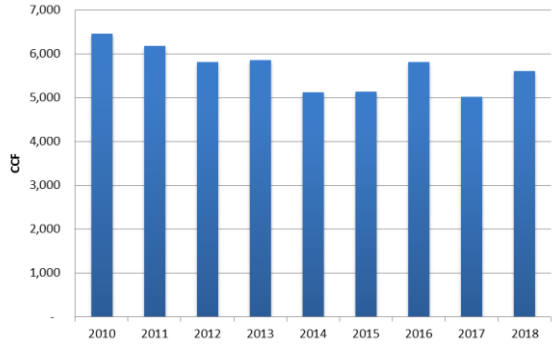


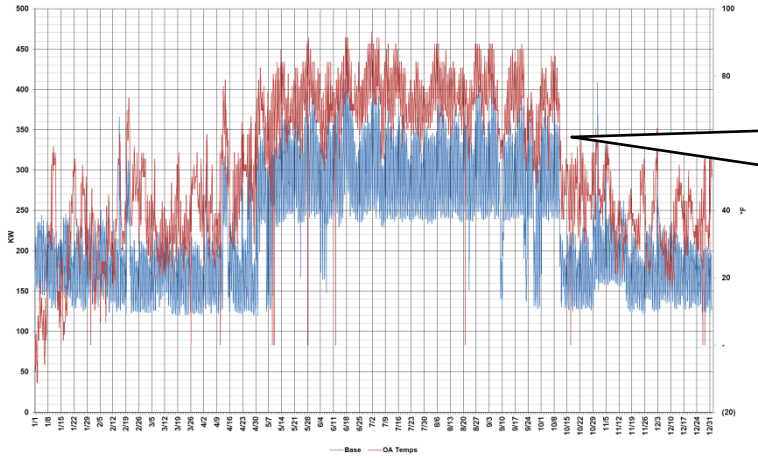
Figure 7-52. 2020 - annual water usage

Electric – slight increase in 2018 but remains low

Natural Gas – significant increase over previous year

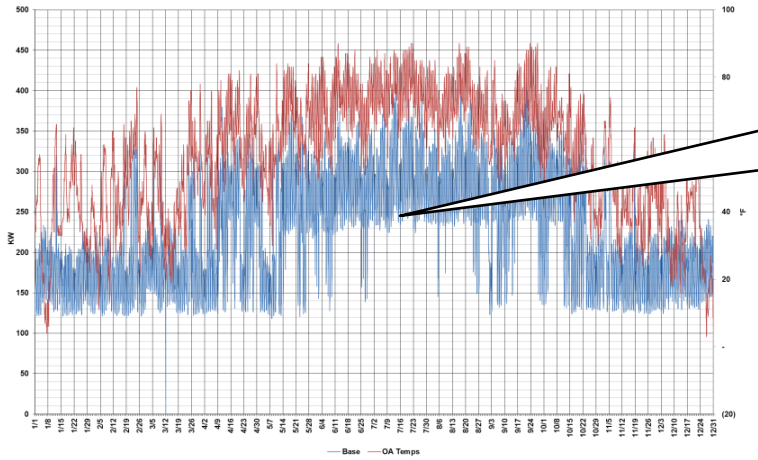
Water – increased in 2018 compared to previous year, but remains lower than 2016

Juvenile Detention Center (2020 Auburn) - Hourly Demand Review



Power usage is higher during the day in the summer than 2017. No night setback in this building.

Figure 7-53. Hourly electric data – 2020 Auburn (2018)



2017 Hourly Data confirms this is a 24/7 facility with limited ability to change electric usage and demand.

Figure 7-54. Hourly electric data – 2020 Auburn (2017)

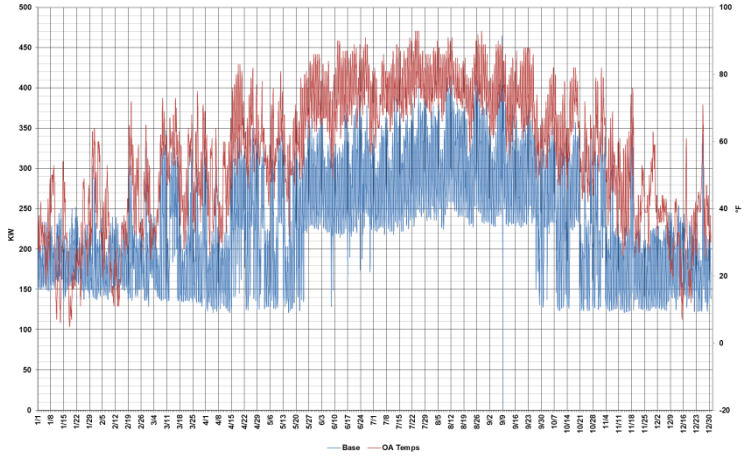
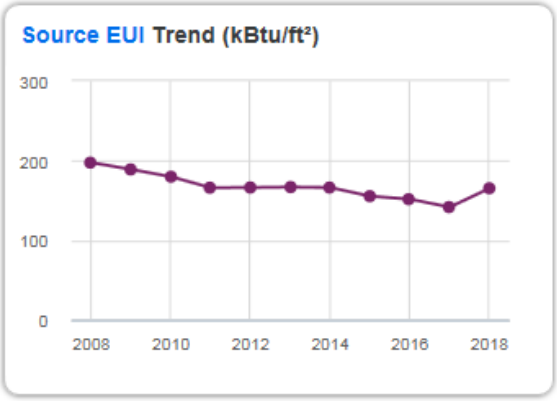


Figure 7-55. Hourly electric data – 2020 Auburn (2016)



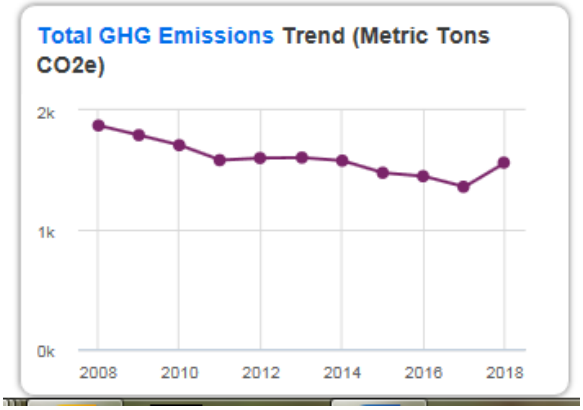


Figure 7-56. 2020 EUI and GHG

Energy Star Score (1-100):

Current Score – 67
Baseline Score – 49
This building has been gradually improving, achieving scores high enough to qualify prior to the Energy Star metric change. However, Detention Facilities cannot receive the award under the current EPA guidelines.

Energy Star Charts:

The EPA's Energy Star website tracks the Energy Use Index (EUI) and the Greenhouse Gas (GHG) emissions annually for a building based on the electricity, natural gas and water usage.

The continued downward trends in both Source EUI and GHG emissions indicate the success of the energy conservation projects.

Energy Star Metrics:

There is no metric for jails and penal spaces, so this building uses office space and residency living space to determine the values in Table 7-8. Based on these metrics, the building is being operated more efficiently every year.

Table 7-8. Energy Star metrics summary – 2020 Auburn

Metric	Energy Baseline (Dec 2006)	Energy Current (Nov 2018)	Change
ENERGY STAR score (1-100)	49	67	18.00 (36.70%)
Source EUI (kBtu/ft^2)	200.8	165.6	-35.20 (-17.50%)
Site EUI (kBtu/ft^2)	97.5	88.7	-8.80 (-9.00%)
Energy Cost ($)	214,505.84	174,879.95	-39625.89 (-18.50%)
Total GHG Emissions (Metric Tons CO2e)	11.5	9.4	-2.10 (-18.30%)
Water Use (All Water Sources) (kgal)	Not Available	Not Available	N/A

Appendix A - Glossary of Terms

BASELINE OR BASEYEAR - The year in which the County began its Energy Conservation Project, the calendar year 1997.

BROKER OR MARKETER - Natural gas marketers, or brokers, are independent companies that arrange alternate rates and terms of service for Primary Gas or Electric supply. Marketers offer the option of different terms of pricing than Duke Energy, such as a fixed rate for a fixed period of time. Marketers arrange a customer's gas or electric supply, but do not deliver the natural gas or provide utility services.

BTU - A British thermal unit (BTU) is a standard unit of energy that is used in the United States. A 5-ton air conditioner that conditions a typical home is equivalent to 60,000 BTU/hour. A 100-watt light bulb dissipates 341 BTU/hour. The BTU is often used as a quantitative specification for the energy-producing or energy-transferring capability of heating and cooling systems, such as furnaces, ovens, refrigerators, and air conditioners.

CCAOSC - County Commissioners' Association of Ohio Service Corp. For the purposes of this report, this refers to the organization with which Hamilton County Facilities is partnered with to provide all natural gas commodities for Hamilton County-owned buildings. Starting in 2019 will also partner for electrical commodities with a five-year contract. The CCAOSC manages these contracts through Palmer Energy for all the Counties in the two programs.

DDC - Direct Digital Control describes computer systems used to monitor, trend, adjust, and control building HVAC (Heating, Ventilating and Air Conditioning) Systems.

DEGREE-DAY - A rough measure used to estimate the amount of heating or cooling required in a given area, defined as the difference between the mean daily temperature and 65 degrees Fahrenheit. Cincinnati typically experiences about 4,500 heating degree-days per year.

DEO - Duke Energy Ohio is the regulated utility provider in Hamilton County.

DERS - Duke Energy Retails Service is the deregulated branch of Duke Energy in the Hamilton County area.

ECM - Energy Conservation Measure, any activity (project, scheduling, replacement, task) with the purpose of saving energy or using energy more wisely.

ESCO - Energy Service Company.

FT RATE - See IT Rate.

ENGINEERING ENERGY PARTNER - Energy service companies or registered professionals, such as architectural and engineering firms, that provide the expertise, services, equipment, and financing without performance contracting guarantees (e.g. ThermalTech Engineering in this report).

GS RATE - See IT Rate

HVAC - Heating, Ventilating and Air Conditioning.

IGA - Investment Grade Audit.

IT RATE - Interruptible Rate Tariff, an optional rate schedule offered by Duke Energy that charges the customer lower transportation prices on natural gas in exchange for Duke Energy's ability to curtail the gas supply to the building during high demand periods. The gas can be purchased on the open market from companies other than Duke Energy. GS stands for General Service (the default residential and commercial rate schedule) and FT stands for Firm Transportation (similar to IT but it cannot be curtailed).

KW - The kilowatt (symbolized kW) is a unit of power measurement used by the utility industry to measure the peak power consumption of buildings. A peak kW of usage costs about $10-15/month.

KWH - The kilowatt-hour (symbolized kWh) is a unit of energy equivalent to one kilowatt (1 kW) of power expended for one hour (1 h) of time. It is commonly used in electrical measurement applications. A 100-watt light bulb operated for 10 hours consumes 1,000 watt-hours or 1 kWh. A kWh costs about $0.03-0.05.

LEED® - Leadership in Energy and Environmental Design, a rating system created by the U.S. Green Building Council to allow the sustainability and energy efficiency of buildings to be quantified and compared. Points are earned for energy and water savings strategies, indoor environmental quality, materials recycling, etc. The rating system has reward levels of certified, bronze, silver, and gold.

LEED-EB:O+M - Certification for Existing Buildings: Operations & Maintenance

LIFE CYCLE COST (LCC) - A financial decision-making calculation for building owners and designers. It provides a means of comparing the net present value or rate-of-return of two or more design alternatives. For each alternative, first costs and annual maintenance and energy costs are combined with financial factors to determine the total cost of ownership over an economic period (typically 20 years for mechanical equipment), allowing the owner to select the piece of equipment that provides the best financial return.

MCF - A unit of measurement used for natural gas, equal to 1,000 cubic feet of gas, or about 1 mmBTU. An MCF costs about $5-10.

NIGHT SETBACK - when HVAC control systems are scheduled off when the building is unoccupied. Normally these setbacks allow the building to rise to 80 degrees in the summertime and drop to 65 degrees in the wintertime before bringing the building system back on to maintain the building temperature.

NORMALIZED - For the purposes of this report, there are two cases of normalization. The first is the method that Duke Energy uses to bill it customers. Meter read dates often occur in the middle of the month. When this happens, the usage and cost is put in the month with the most days represented (e.g. if a bill arrives on March 1st for the dates of Jan 21 through Feb 21, that is considered the February bill). The second occurrence of normalization occurs in comparing successive calendar years to the baseline year of this report. To accurately determine if energy usage and cost have increased or decrease, the changing cost of gas and electric and effects of weather are factored out. This is accomplished by acquiring the annual degree-days and building a ratio from each year to the base year, then determining the minimum utility usage of a building that is independent of external stimuli (e.g. computers, lights, elevators). The "Normalized" Master Spreadsheet is then created.

OPFMA – Ohio Public Facilities Maintenance Association

PAYBACK PERIOD - The amount of time required for an asset to generate enough savings to offset the initial outlay for the asset.

PC - Performance Contractor or ESCO.

PROJECTED SAVINGS - In a savings-based financing agreement, refers to the expected annual dollar value of the reduced energy consumption as a result of conservation measures.
PUCO – Public Utilities Commission of Ohio.

SAVINGS-BASED FORMULA - The formula (calculation of savings procedure) specified in the contract used to determine savings, usually involving four steps:

1. Determine actual historical usage and contributing operating conditions to form a base year
2. Adjust base year actual usage for variations (temperature, occupancy, etc.) to form a baseline
3. Subtract actual usage from adjusted baseline consumption
4. Calculate savings by multiplying the units of energy saved by the current cost per unit.

*Note: Calculations for electrical demand savings are considered part of the formula but are computed separately.

SOURCE EUI – The total amount of all raw fuel required to operate a property, including losses that take place during generation, transmission, and distribution of the energy, divided by the property square foot.

USGBC – U.S. Green Building Council, a private 501(c)3 non-profit that promotes sustainability in building design, construction, and operation, and developed the LEED rating system.

Appendix B - Accomplishments

Since the implementation of the Energy Conservation Master Plan in 1998, County Facilities has implemented the following energy conservation measures:

All Buildings

1998 Hamilton County Facilities collaborated with an outside firm, ThermalTech Engineering, to monitor monthly energy usage. To date, this partnership has discovered a billing error at the 800 Broadway building and an electric tariff billing error at an MRDD facility.

1999 The CCAOSC Board of Trustees authorized the establishment of a Natural Gas Program for CCAOSC members, saving counties money through pre-payment and aggregation (buying as a group).

2000 Taxable bonds totaling $29,890,000 were issued by Hamilton County on October 31 to assist the CCAOSC and 30 CCAOSC Natural Gas Program member counties. The program began November 1, with Exelon Energy managing the gas portion of the program which ended in May 2009

Life Cycle Cost and Total Cost of Ownership to purchase large mechanical equipment (e.g. boilers, chillers, air handlers, and cooling towers). Facilities began purchasing deregulated natural gas with the CCAOSC in October 2000.

Implement FT gas rate for all buildings (Duke Energy Resources won bid and later went defunct).

2009 County Facilities has accepted deregulated electricity bids twice to try to beat Duke Energy prices (currently no bidders have ever been able to meet County bid requirements and Duke Energy prices). In 2010, the County entered into a contract with Duke Energy Retail Services for commodity electricity for three years.

A three-year contract with Duke Energy Retail Purchasing deregulated electric power, reducing the cost of electric power by 20%.

2012 The deregulated purchase of electric power continued with the award of a three-year contract with First Energy.

2015 The deregulated purchase of electric power continued with the award of a three-year contract with Dynegy Energy Services.

The County entered into a new deregulated purchase of natural gas through CCAOSC for a three-year period.

2018 The County entered into a contract with Dynegy Energy Services for commodity electricity for five-year period (2019 thru 2023) thru an electrical purchase agreement through CCAOSC.

The County successfully certified seven buildings under the Department of Energy's Energy Star Program including 230 East Ninth, 250 William Howard Taft, 800 Broadway, Alms & Doepke, County Administration, Courthouse and the Sheriff Patrol Headquarters.

2019 The County entered into a new 5-year deregulated purchase of natural gas agreement through CCAOSC, which Ralph W. Linne is a sitting board member and member of the Executive Energy Committee since 2015.

230 East 9th

1994 Completed upgrade of all HVAC and electrical systems. Upgrade included new DDC building automation system complete with night setback and overrides that turn off unscheduled starts of the heating and cooling system automatically after two hours of unoccupied use. Power Logic electrical panels include a two-hour override for the lighting system. A complete

variable-flow air handling system with similar zones for better space control and varicone air handlers on roof to handle part load conditions within the building.

2012 Implemented Phase 1 of energy conservation measures from Ameresco Investment Grade Audit, including a high-efficiency condensing boiler and domestic water heater upgrade, boiler flue relining and boiler economizer repair, cooling tower replacement, and condensate reclaim from rooftop units (RTU).

250 William Howard Taft

2009 Replaced chiller with high-efficiency Trane Screw Chiller with VFD.

Upgraded pumps and pumping strategy to variable secondary flow.

2010 Replaced existing boilers with new high-efficiency hot water condensing boilers.

2013 Upgraded outdoor lighting to high-efficiency lighting fixtures.

2014 Implemented Phase 2 of energy conservation measures from Ameresco Investment Grade Audit, including lighting upgrades, water conservation, HVAC, and controls upgrades.

800 Broadway

1999 Eliminated unnecessary space cooling during unoccupied periods of the cooling season

Turned off Waiting Room AHU fans with timeclocks during unoccupied periods

Used night setback to eliminate unnecessary space heating and cooling during unoccupied periods

Used small compressors in the computer room cooling units in lieu of the large building chiller during the heating season

Added sewer deduction water meter for cooling tower and boiler make-up water

Insulated bare steam and condensate piping and related equipment in various parts of the building

Installed fluorescent lighting fixtures in place of incandescent units

Upgraded secondary chilled water pump VFD controls to allow variable speed operation of pump, and blocked all bypass ports of 3-way valves to promote variable flow.

Installed two high-efficiency power burner gas water heaters and shut down large steam boilers during the summer.

Combined cooling tower operation to take advantage of low-speed fan operation

Replaced the 600-ton Trane chiller with a high-efficiency chiller

Modified cooling tower piping and fan controls to allow both towers to serve one chiller at lower fan speed

Upgraded building automation to full DDC system, utilizing scheduling and setbacks

Programmed "Near-optimized control of Chiller Plants" into DDC system

2000 IPAC Phase I

2001 Upgraded building automation to full DDC system, utilizing scheduling and setbacks

IPAC Phase II

2002 Upgraded building automation to full DDC system, utilizing scheduling and setbacks

IPAC Phase III

2003 Replaced outdated cooling towers with new counterflow cooling towers equipped with VFDs and two-speed motors

2003 Discovered $50,000 billing error from Duke. Recovered cost as a credit for local utility for this building.

2004 Replaced old boilers with new higher efficiency boilers.

2013 Implemented Phase 1A energy conservation measures from Ameresco Investment Grade Audit, including lighting upgrades, controls/recommissioning, VFDs on pumps or fan motors, water conservation measures, heat exchanger package, domestic water booster pump package, phone room A/C, computer room consolidation, OPFMA training, and energy behavior modification training.

2017 Recommission controls for many floors to reset steam pressure and temperature, eliminate simultaneous heating and cooling, and update setback schedules.

County Administration Building

1999 Insulated bare steam and condensate piping and related equipment in various parts of the building.

2005 Replaced old evaporative chiller on tenth floor with a high-efficiency air-cooled chiller purchased through life cycle cost analysis.

Replaced Rooftop Units 1 & 2 with new Trane Intellipak systems

2012 Implemented Phase 1 energy conservation measures from Ameresco Investment Grade Audit, including replacement of existing steam boilers with high-efficiency condensing boilers, domestic water heater replacement, and recovery of heat rejection from computer room A/C units.

2017 Upgraded controls on all air handling units in the building to full DDC controls, upgraded economizer control on all lobby air handlers to increase airflow to maximum allowed while keeping lobby neutral in pressure, replaced controller on DATAC computer unit on fifth floor to take advantage of free cooling when its available.

Alms & Doepke Building

1994 Utilized low-VOC materials in paint, furniture, and carpet.

Met LEED criteria for daylighting/view access to staff

Installed a high-efficiency charcoal filtration system with 100% outdoor air

Mechanical system flush-out ran one week at high temperatures to encourage early off-gassing.

Monitored mechanical system off site to ensure the building systems continued to operate at best levels

Mechanical system computer controls set to return to appropriate setting when changed manually to inappropriate settings.

High-efficiency lighting installed

Utilized reused/recycled content materials in flooring (primarily carpeting), systems furniture, and ceiling tile

1999 Insulated domestic hot water storage tank in penthouse.

Insulated bare steam and condensate piping and related equipment in various parts of the building

Upgraded insulation values in building.

2012 Implemented Phase 1 energy conservation measures from Ameresco Investment Grade Audit, including replacement of domestic water heaters with a heat pump water heater.

2016 Added six VAV boxes with hot water reheat to the first floor to address tenant comfort during winter Recommissioned controls.

County Courthouse

1999 Replaced constant-volume air handlers with energy-efficient VAV units under DDC control.

2003 Upgraded boiler plant to utilize separate condensate receiver and deaerator to allow boiler stack economizers to preheat feedwater, resulting in more efficient steam production.

2004 Converted to IT Rate transport gas supply from Duke Energy (Commodity purchased through CCAOSC).

2006 Modified Boiler DDC system to fire boilers more efficiency and prevent moisture carryover during steam production.

2013 Implemented Phase 1A of energy conservation measures from Ameresco Investment Grade Audit, including lighting upgrades, controls/recommissioning, VFDs on pumps or fan motors, water conservation measures, domestic water heater, blowdown heat recovery, computer room A/C modifications, well water makeup, OPFMA training, and energy behavior modification training.

Used State Term Contracting to upgrade inefficient DX equipment that provides cooling to several sections of the Courthouse requiring after-hour space conditioning.

2016 New Condensate Receiver and Vacuum Pump.

Justice Center

2001 Replaced cooling towers with new cooling towers equipped with VFDs.

2006 Recommissioned the DDC system to eliminate obsolete and broken control components.

Implemented better control of schedules and outdoor air control

Repaired system back to original specifications

2006 Replaced dual duct boxes in Sheriff's Offices to improve comfort and energy usage.

2007 Installed VFD drives on stairwell pressurization fans to reduce amount of conditioned air being exhausted from building.

2010 Replaced Domestic Water Booster pumping system with higher efficiency Grundfos VFD domestic water pumps.

2013 Implemented Phase 1A of energy conservation measures from Ameresco Investment Grade Audit, including lighting upgrades, controls/recommissioning, VFDs on pumps or fan motors, water conservation measures, chiller replacement, heat pump water heaters, solar water heaters, control area HVAC, OPFMA training, and energy behavior modification training.

2017 Upgrade Controls and Sequences to take advantage of additional schedule savings.

2018 Replace dual domestic water backflow preventers at the Justice Center

2020 Auburn (the Juvenile Jail)

2010 Installed new high-efficiency condensing boilers.

2014 Implemented Phase 2 of energy conservation measures from Ameresco Investment Grade Audit, including lighting upgrades, water conservation, VFD, and mechanical upgrades.

911 Communications Center

2014 Implemented Phase 2 of energy conservation measures from Ameresco Investment Grade Audit, including lighting upgrades, water conservation, heat recovery, HVAC and controls upgrades.

Public Works Garage

2014 Implemented Phase 2 of energy conservation measures from Ameresco Investment Grade Audit, including lighting upgrades, water conservation, HVAC, and controls upgrades.

Sheriff Patrol Headquarters

2014 Implemented Phase 2 of energy conservation measures from Ameresco Investment Grade Audit, including lighting upgrades, water conservation, HVAC and controls upgrades.

2016 Replaced Air Handler Units 2 and 6 with new higher efficiency equipment. Equipped Rooftop Unit 2 with 100% economizer for free cooling

2017 Replaced Rooftop Unit RTU-5 with new higher efficiency equipment with 100% airside economizers. Replaced old water heater with new high efficiency heating hot water boilers and upgraded all controls for the RTU-5 and Heating Hot Water Loop including a complete air and water Balance of the second floor.

Winton Road Records Center

2001 Installed Air Handling Unit with no economizers to reduce the humidification costs for archive storage facilities. HVAC load calculations indicated that use of free cooling outdoor air would use more energy than recirculation. The County acquired a variance from Building Department for this installation.

2014 **I**mplemented Phase 2 of energy conservation measures from Ameresco Investment Grade Audit, including lighting upgrades, water conservation, HVAC, and controls upgrades.

237 William Howard Taft (building was sold in December 2011)

2001 Purchased and installed two new higher efficiency boilers using the Life Cycle Cost procedure and modern control strategies.

2006 Purchased and installed a new 400-ton chiller using the Life Cycle Cost resolution interlocked with DDC system to provide optimal start/stop and night setback.

Added VFD to primary chilled water pump for better flow control through chiller

Controls contractor added additional programming for better backup control of building while in setback over weekends.

2007 Upgraded DDC system with night setback programming.

2009 Replaced HVAC system and upgraded DDC controls, chilled water, and heating hot water.

Appendix C - History

Energy Conservation Master Plan

In 1998, County Facilities began an Energy Conservation Master Plan study with local engineering firm ThermalTech Engineering. The County selected ThermalTech Engineering because of their long-standing tradition of engineering energy management (they have performed over 100 Federal Title III energy audits, have a full understanding of Duke Energy's rate tariffs, and have engineering design experience to assist with installations).

In 2003, the Master Plan was updated with a grant from Rebuild America and was updated again in 2011 after Energy Audits were performed by Ameresco.

Performance Contract

Ameresco performed several phases of Investment Grade Audits through a performance contract per House Bill 295/300. Phase 1 included Alms & Doepke, A&D Parkhaus Garage, County Administration, and 230 East 9th. Annual projected savings to be $403,000. The Energy efficiency and conservation block Grant Program (EECBG) cofounded this project with a $1,450,000 grant. Duke Energy Smart $aver incentives amounting to $284,500 were awarded to fund the implementation of the energy and water conservation measures identified. These projects were implemented in 2012.

Phase 1A audits included the Courthouse, Justice Center, and 800 Broadway. Annual projected savings to be $767,000. EECBG grants totaling $1,352,901 co-funded this project, along with $72,250 of incentives through the Duke Energy Smart $aver program. The recommended energy and water conservation projects were implemented in 2013.

Phase 2 audits included 2020 Auburn, 911 Communications Center, Sheriff Patrol HQ, 250 William Howard Taft, Coroner's Facility, Clerk of Courts Records, 264 William Howard Taft, Public Works Garage, and 2611 Highland. Annual projected savings to be $151,000. The recommended energy and water conservation projects were implemented in 2014.

Cinergy Resources

Opportunities to acquire natural gas supplies through deregulation were identified, and Facilities and ThermalTech prepared bid documents. A broker-supplied natural gas commodity from Duke Energy Resources was secured in 1999. Shortly after the program started, Cinergy Resources went defunct and the County was forced back onto CG&E natural gas.

CCAO Service Corporation Natural Gas Programs

In 1999, the CCAOSC Board of Trustees authorized the establishment of a Natural Gas Program for CCAOSC members. The 30 counties that signed up for the program saved money in two ways: Pre-payment and Aggregation (buying as a group). Taxable bonds totaling $29,890,000 were issued by Hamilton County on October 31, 2000 to assist the CCAOSC and 30 member counties. The program began November 1, 2000 with Exelon Energy managing the gas portion of the program and ended in May 2009.

The County signed on to a new program with the CCAOSC in May 2009, with Palmer Energy acting as the Energy Broker. By 2019, there were over 56 member counties. Presently the Facilities Director, Ralph Linne, serves on the Energy Executive Committee and is the representative for Hamilton County.

Procurement of Electricity from the Deregulated Market

County Facilities has also attempted to buy electricity on the deregulated market and has produced bid packages for this purpose. Jim Clarkson of Resource Management, Inc. prepared the bid packets along with ThermalTech Engineering. The prices from the first bid were not low enough to project any

savings to the County, so no bids were accepted. The second bid was not executable due to contract and pricing restrictions by the marketers. A contract could not be agreed upon fast enough to keep the bid prices on bid day intact.

Bids were opened for a third time in 2010, resulting in a three-year contract with Duke Energy Retail, which lowered the cost of electric power by 20%. In 2013, the bid was again successful, awarding First Energy Solutions a three-year contract for calendar years 2013 through 2015.

Bids were opened for a third time in 2015, resulting in a three-year contract with Dynegy Energy Services, which kept electric cost within 5% of the previous contract for the next three years; 2016 through 2018.

CCAO Service Corporation Electric Program

In 2018, Hamilton County signed an agreement for CCAOSC to act as procurement agent for electrical power. Palmer Energy secured bids for the County and a five-year contract with Dynegy Energy Services was awarded for 2019 thru 2023. The rate was lower than the previous agreement with Dynegy Energy Services.

Energy Manager

County Facilities has had two full-time energy managers since 2001 but has not had this position filled for several years. In lieu of a having a full-time employee, ThermalTech Engineering has provided monthly review and reconciliation of utility bills, prepared the RFPs for electric power, updated the Master Plan, and assisted in the preparation of this report. Presently, they analyze trends and reports monthly on County utility usage in addition to preparing annual Energy Reports.

List Energy-Related Awards

2018

- EPA Energy Star Awards for Records Center, Patrol Headquarters, 230 East Ninth, 250 William Howard Taft, County Administration Building, Alms & Doepke, Sheriff Patrol Headquarters and the Hamilton County Courthouse.

2017

- EPA Energy Star Awards for 230 East Ninth, 250 William Howard Taft, County Administration Building, Alms & Doepke and the Hamilton County Courthouse.

2016

- EPA Energy Star Awards for 230 East Ninth, 250 William Howard Taft, County Administration Building, Alms & Doepke and the Hamilton County Courthouse.

2015

- 2016 FMXcellence Award - Hamilton County Facilities Department
- 2016 Facility Executive of the Year - Ralph W. Linne - Winner
- Energy Star Awards for 250 William Howard Taft, 230 East 9th, 800 Broadway Building, Alms & Doepke (Jobs & Family Services and County Administration Building)

2014

- Energy Star Awards for 800 Broadway, 230 East 9th, and County Administration Building
- LEED-EB:O+M Certification - 800 Broadway Building (5-Year Certification)
- Business Courier Green Building Awards - Finalist

2013

- EPA Energy Star Awards for 800 Broadway and 230 East 9th Street
- Business Courier Green Awards - Participant
- Building Owners and Managers Association (BOMA) of Cincinnati Highest Performing Building 2nd Place for County Administration Building

- BOMA of Cincinnati Most Improved Performance 2nd Place for County Courthouse
- BOMA of Cincinnati Most Improved Performance 3rd Place for Alms & Doepke

2012
- EPA Energy Star Award for 800 Broadway and County Administration Building
- Business Courier Green Awards - Finalist

2011
- EPA Energy Star Award for 800 Broadway, County Administration Building, and 230 East Ninth Street

2010
- EPA Energy Star Award for 800 Broadway Building
- Who's Who 2009: Leaders in Energy Management and Sustainability

2009
- EPA Energy Star Award for 800 Broadway Building

2008
- EPA Energy Star Award for 800 Broadway Building

2006
- Governor's Award for Energy Excellence - Honorable Mention

2005
- Governor's Award for Energy Excellence - Second Place Finisher
- Local and Regional TOBY (The Office Building of the Year) for 800 Broadway

2004
- Governor's Award of Energy Excellence - First Place Finisher
- Alliance to Save Energy - Participant

2002
- Rebuild America Energy Grant Recipient - Winner

2001
- NACO Award for Life Cycle Cost Purchasing - Winner
- Regional TOBY (The Office Building of the Year) for the County Courthouse

2000
- Local TOBY (The Office Building of the Year) for the County Courthouse
- Regional TOBY (The Office Building of the Year) for 230 East Ninth

1999
- Local TOBY (The Office Building of the Year) for 230 East Ninth

Appendix D - Conversions & Methodologies

The following equations, references, unit conversions and methodologies were used in the creation of this report and with the Energy Conservation Project from 1998- present;

References

- Archibus - http://hamiltoncounty.asset-fm.com/archibus/login.axvw
- Energy Watchdog - www.pro.energywatchdog.com
- EPA Energy Star -https://portfoliomanager.energystar.gov/pm/login.html
- ASHRAE - https://www.ashrae.org/
- AEE Handbook
- HVAC Equations, Data and Rules of Thumb, Second Edition
- Guide to Energy Management, Fourth Edition
- Trane Trace
- DOE eQuest
- www.degreday.net
- www.duke-energy.com
- Engineering Spreadsheets created by ThermalTech Engineering for the express purpose of tracking and reporting data for this report.

Methodologies

- Linear Regression Modeling for Weather Normalization
- Excel Spreadsheet for Duke Tariff reconciliation for electric and natural gas.
- Excel Spreadsheet Demand Curve Analysis for load profiles.
- Life Cycle Cost Analysis for equipment purchases during Energy Conservation Projects.

Popular Conversions

Unit	Name	Definition/Notes
BTU	British Thermal Unit	Heat required to raise 1 lb water 1 degree F
C	100	equals one hundred (100).
CCF	100 cubic feet	100 cubic feet (cf) of natural gas.
MCF	1000	1000 cubic feet (cf) of natural gas
M	1000	equals one thousand for HVAC (not Mega)
MM	1,000,000	One Million for HVAC Applications.
MMBtu	1,000,000	One Million BTU's
Therm	= 100,000 BTU	Btu/CF cf; one Ccf = 102,300 Btu or 1.023 therms
CF ng	= 1023 btuh	Cubic Feet of Natural Gas
CCF ng	= 102,300 btu's	or 1.023 therms
MCF ng	= 1.023 MMbtu	or 10.23 therms
W	Watts	Watts
K	1000	Kilo
KW	= 1000W	1000 Watts
KWH	Kilowatt-hours	Kilowatt-Hours
1 W	= 3.413 btuh	normally the hours is added to BTU
1 KW	= 3413 btuh	1000 times the amount of a Watt
1 KW motor	to Horsepower	x 1.34 HP
1 HP motor	to KW	x 0.745 KW
PPH	Steam	Pounds Per Hour of Steam
1 PPH	x 970	= btuh (BTU per hour
Kgal	Kilogal	1000 Gallons of Water

$/Kgal	$/CCF	= 748/100 (multiply $/kgal by 0.748 to get $/CCF)
1 CF water	= 7.48 gallons	1 CCF = .748 kgal
1 HP	1 Horsepower (boiler)	= 33479 btuh
1 HP	1 Horsepower (boiler)	= 12 SF of heating surface
1 HP	1 Horsepower (boiler)	= 34.5 PPH steam
Ohio Special	Boiler Rating	> 360 SF of Heating Surface or
1 Ton AC	1 ton of cooling	12,000 btuh

Equations

Airside System

$$H_S = 1.08 x CFM x \Delta T$$
$$H_S = 1.1 x CFM x \Delta T$$
$$H_L = 0.68 x CFM x \Delta W_{GR.}$$
$$H_L = 4840 x CFM x \Delta W_{LB.}$$
$$H_T = 4.5 x CFM x \Delta h$$
$$H_T = H_S + H_L$$
$$SHR = \frac{H_S}{H_T} = \frac{H_S}{H_S + H_L}$$
$$H_S = 1.08 \frac{BTU\ min.}{hr\ ft^3\ °F} x CFM x \Delta T$$
$$H_L = 0.68 \frac{BTU\ min.\ Lb\ DA}{hr\ ft^3\ Gr\ H_2O} x CFM x \Delta W$$
$$H_T = 4.5 \frac{Lb\ min.}{hr\ ft^3} x CFM x \Delta h$$
$$H_T = H_S + H_L$$

$H_S = Sensible\ Heat\ \left(\frac{BTU}{hr}\right)$
$H_L = Latent\ Heat\ \left(\frac{BTU}{hr}\right)$
$H_T = Total\ Heat\ \left(\frac{BTU}{hr}\right)$
$\Delta T = Temperature\ Difference\ (°F)$
$\Delta W_{GR.} = Humidity\ Ratio\ Difference\ \left(\frac{GR.H_2O}{Lbs.DA}\right)$
$\Delta W_{LB.} = Humidity\ Ratio\ Difference\ \left(\frac{Lbs.H_2O}{Lbs.DA}\right)$
$\Delta h = Enthalpy\ Difference\ \left(\frac{BTU}{Lbs.DA}\right)$
$CFM = Air\ Flow\ Rate\ (Cubic\ Feet\ per\ Minute)$
$SHR = Sensible\ Heat\ Ratio$
$m = Mass\ flow\ \left(\frac{Lbs.DA}{hr}\right)$
$c_a = Specific\ Heat\ of\ Air\ \left(0.24 \frac{BTU}{Lbs.DA\ °F}\right)$
$DA = Dry\ Air$

Waterside System

$$H = 500xGPMx\Delta T$$
$$GPM_{EVAP} = \frac{TONSx24}{\Delta T}$$
$$GPM_{COND} = \frac{TONSx30}{\Delta T}$$

$$H = Total\ Heat\ \left(\frac{BTU}{hr}\right)$$
$$H = 500\frac{BTU\ min.}{hr\ gal\ °F}xGPMx\Delta T$$
$$H = Total\ Heat\ \left(\frac{BTU}{hr}\right)$$

$\Delta T = Temperature\ Difference\ (°F)$
$GPM = Water\ Flow\ Rate\ (Gallons\ per\ Minute)$
$GPM = Water\ Flow\ Rate\ (Gallons\ per\ Minute)$
$\Delta T = Temperature\ Difference\ (°F)$
$TONS = Air\ Conditioning\ Load\ (Tons)$
$GPM_{EVAP} = Evaporator\ Water\ Flow\ Rate\ (Gallons\ per\ Minute)$
$GPM_{COND} = Condenser\ Water\ Flow\ Rate\ (Gallons\ per\ Minute)$
$c_w = Specific\ heat\ of\ Water\ \left(1.0\frac{BTU}{Lbs \cdot H_20}\right)$

Air Change Rate

$$\frac{AC}{HR} = \frac{CFMx60}{VOLUME}$$
$$CFM = \frac{\frac{AC}{HR}xVOLUME}{60}$$
$$\frac{AC}{HR} = Air\ Change\ Rate\ per\ Hour$$

$CFM = Air\ Flow\ Rate\ (Cubic\ Feet\ per\ Minute)$
$VOLUME = Space\ Volume\ (Cubic\ Feet)$

Fan Laws

$$\frac{CFM_2}{CFM_1} = \frac{RPM_2}{RPM_1}$$
$$\frac{SP_2}{SP_1} = \left[\frac{CFM_2}{CFM_1}\right]^2 = \left[\frac{RPM_2}{RPM_1}\right]^2$$
$$\frac{BHP_2}{BHP_1} = \left[\frac{CFM_2}{CFM_1}\right]^3 = \left[\frac{RPM_2}{RPM_1}\right]^3 = \left[\frac{SP_2}{SP_1}\right]^{1.5}$$
$$BHP = \frac{CFMxSPxSP.GR.}{6356xFAN_{EFF}}$$
$$MHP = \frac{BHP}{M/D_{EFF}}$$

$CFM = Cubic\ Feet/Minute$
$RPM = Revolutions/Minute$
$SP = in.W.G.$

$BHP = Break\ Horsepower$
$Fan\ Size = Constant$
$Air\ Density = Constant$
$SP.GR.(Air) = 1.0$
$FAN_{EFF} = 65 - 85\%$
$M/D_{EFF} = 80 - 95\%$
$M/D = Motor/Drive$

Pump Laws

$$\frac{GPM_2}{GPM_1} = \frac{RPM_2}{RPM_1}$$
$$\frac{HD_2}{HD_1} = \left[\frac{GPM_2}{GPM_1}\right]^2 = \left[\frac{RPM_2}{RPM_1}\right]^2$$
$$\frac{BHP_2}{BHP_1} = \left[\frac{GPM_2}{GPM_1}\right]^3 = \left[\frac{RPM_2}{RPM_1}\right]^3 = \left[\frac{HD_2}{HD_1}\right]^{1.5}$$
$$BHP = \frac{GPMxHDxSP.GR.}{3960xPUMP_{EFF}}$$
$$MHP = \frac{BHP}{M/D_{EFF}}$$
$$VH = \frac{V^2}{2g}$$
$$HD = \frac{Px2.31}{SP.GR.}$$

$GPM = Gallons/Minute$
$RPM = Revolutions/Minute$
$HD = ft.H_2O$
$BHP = Break\ Horsepower$
$Pump\ Size = Constant$
$Water\ Density = Constant$
$SP.GR. = Specific\ Gravity\ of\ Liquid\ with\ respect\ to\ Water$
$SP.GR.(Water) = 1.0$
$PUMP_{EFF} = 60 - 80\%$
$M/D_{EFF} = 85 - 95\%$
$M/D = Motor/Drive$
$P = Pressure\ in\ psi$
$VH = Velocity\ Head\ in\ ft.$
$V = Velocity\ in\ ft./sec$
$g = Acceleration\ due\ to\ Gravity\ (32.16\ ft./sec^2)$

Steam and Condensate

$$\frac{LBS.STM.}{hr} = \frac{BTU/hr}{H_{FG}} = \frac{BTU/hr}{960}$$
$$\frac{LBS.STM.COND.}{hr} = \frac{EDR}{4}$$
$$EDR = \frac{BTU/hr}{240}$$
$$\frac{LBS.STM.COND.}{hr} = \frac{GPMx500xSP.GR.xC_wx\Delta T}{H_{FG}}$$
$$\frac{LBS.STM.COND.}{hr} = \frac{CFMx60xDxC_ax\Delta T}{H_{FG}}$$
$$\frac{LBS.STM.COND.}{hr} = \frac{GPM(WATER)x\Delta T}{2}$$

$$\frac{LBS.STM.COND.}{hr} = \frac{GPM(FUEL\ OIL)x\Delta T}{4}$$
$$\frac{LBS.STM.COND.}{hr} = \frac{CFM(AIR)x\Delta T}{900}$$

$STM. = Steam$
$GPM = Quantity\ of\ Liquid\ in\ Gallons\ per\ Minute$
$CFM = Quantity\ of\ Gas\ or\ Air\ in\ Cubic\ Feet\ per\ Minute$
$SP.GR. = Specific\ Gravity$
$D = Density\ in\ Lbs./cubic\ feet$
$C_a = Specific\ Heat\ of\ Air\ (0.24\ BTU/Lb)$
$C_w = Specific\ Heat\ of\ Water\ (1.00\ BTU/Lb)$
$H_{FG} = Latent\ Heat\ of\ Steam\ in\ BTU/Lbs.at\ Steam\ Design\ Pressure\ (ASHRAE\ Fundamentals)$
$\Delta T = Final\ Temperature\ minus\ Initial\ Temperature$
$EDR = Equivalent\ Direct\ Radiation$

Mixed Air Temperature

$$T_{MA} = \left(T_{ROOM}x\frac{CFM_{RA}}{CFM_{SA}}\right) + \left(T_{OA}x\frac{CFM_{OA}}{CFM_{SA}}\right)$$
$$T_{MA} = \left(T_{RA}x\frac{CFM_{RA}}{CFM_{SA}}\right) + \left(T_{OA}x\frac{CFM_{OA}}{CFM_{SA}}\right)$$

$CFM_{SA} = Supply\ Air\ CFM$
$CFM_{RA} = Return\ Air\ CFM$
$CFM_{OA} = Outside\ Air\ CFM$
$T_{MA} = Mixed\ Air\ Temperature\ (°F)$
$T_{ROOM} = Room\ Design\ Temperature\ (°F)$
$T_{RA} = Return\ Air\ Temperature\ (°F)$
$T_{OA} = Outside\ Air\ Temperature\ (°F)$

Psychrometrics

$$W = 0.622x\frac{P_W}{P - P_W}$$
$$RH \cong \frac{W_{ACTUAL}}{W_{SAT}}x100\%$$
$$RH = \frac{P_W}{P_{SAT}}x100\%$$
$$H_S = m\ x\ C_p\ x\ \Delta T$$
$$H_L = L_v\ x\ m\ x\ \Delta W$$
$$H_T = m\ x\ \Delta h$$
$$W = \frac{(2501 - 2.381T_{WB})(W_{SAT\,WB}) - (T_{DB} - T_{WB})}{2501 + 1.805T_{DB} - 4.186T_{WB}}$$
$$W = \frac{(1093 - 0.556T_{WB})(W_{SAT\,WB}) - (0.240)(T_{DB} - T_{WB})}{1093 + 0.444T_{DB} - T_{WB}}$$

$W = Specific\ Humidity, Lbs.H_2O/Lbs.DA\ or\ GR.H_2O/Lbs.DA$
$W_{ACTUAL} = Actual\ Specific\ Humidity, Lbs.H_2O/Lbs.DA\ or\ GR.H_2O/Lbs.DA$
$W_{SAT} = Saturation\ Specific\ Humidity\ at\ the\ Dry\ Bulb\ Temperature$
$W_{SAT\,WB} = Saturation\ Specific\ Humidity\ at\ the\ Web\ Bulb\ Temperature$
$P_W = Partial\ Pressure\ of\ Water\ Vapor, Lb./sq.ft.$
$P = Total\ Absolute\ Pressure\ of\ Air/Water\ Vapor\ Mixture, Lb./sq.ft.$
$P_{SAT} = Saturation\ Partial\ Pressure\ of\ Water\ Vapor\ at\ the\ Dry\ Bulb\ Temperature, Lb./sq.ft.$
$RH = Relative\ Humidity, \%$
$H_S = Sensible\ Heat, BTU/hr$

$H_L = Latent\ Heat, BTU/hr$
$H_T = Total\ Heat, BTU/hr$
$m = Mass\ Flow\ Rate, Lbs.DA/hr\ or\ Lbs.H_2O/hr$
$c_p = Specific\ Heat, Air - 0.24\ BTU/Lbs.DA, Water - 1.0\ BTU/Lbs.H_2O$
$T_{DB} = Dry\ Bulb\ Temperature, °F$
$T_{WB} = Wet\ Bulb\ Temperature, °F$
$\Delta T = Temperature\ Difference, °F$
$\Delta W = Specific\ Humidity\ Difference, Lbs.H_2O/Lbs.DA\ or\ GR.H_2O/Lbs.DA$
$\Delta h = Enthalpy\ Difference, BTU/Lbs.DA$
$L_v = Latent\ Heat\ of\ Vaporization, BTU/Lbs.H_2O$

Ductwork

$$TP = SP + VP$$
$$VP = \left[\frac{V}{4005}\right]^2 = \frac{(V)^2}{(4005)^2}$$
$$V = \frac{Q}{A} = \frac{Qx144}{WxH}$$
$$D_{EQ} = \frac{1.3x(AxB)^{.625}}{(A+B)^{.25}}$$

$TP = Total\ Pressure$
$SP = Static\ Pressure, Friction\ Losses$
$VP = Velocity\ Pressure, Dynamic\ Losses$
$V = Velocity, ft./min$
$Q = Flow\ through\ Duct, CFM$
$A = Area\ of\ Duct, sq.ft.$
$W = Width\ of\ Duct, in.$
$H = Height\ of\ Duct, in.$
$D_{EQ} = Equivalent\ Round\ Duct\ Size\ for\ Rectangular\ Duct, in.$
$A = One\ Dimension\ of\ Rectangular\ Duct, in.$
$B = Adjacent\ Side\ of\ Rectangular\ Duct, in.$

Air Conditioning Condensate

$$GPM_{AC\ COND} = \frac{CFMx\Delta W_{LB}}{SpVx8.33}$$
$$GPM_{AC\ COND} = \frac{CFMx\Delta W_{GR}}{SpVx8.33x7000}$$

$GPM_{AC\ COND} = Air\ Conditioning\ Condensate\ Flow\ (gal./min)$
$CFM = Air\ Flow\ Rate\ (cu.ft./min)$
$SpV = Specific\ Volume\ of\ Air\ (cu.ft./Lbs.DA)$
$\Delta W_{LB} = Specific\ Humidity\ (Lbs.H_2O/Lbs.DA)$
$\Delta W_{GR} = Specific\ Humidity\ (GR.H_2O/Lbs.DA)$

Efficiencies

$$COP = \frac{BTU\ OUTPUT}{BTU\ INPUT} = \frac{EER}{3.413}$$
$$EER = \frac{BTU\ OUTPUT}{WATTS\ INPUT}$$
$$\frac{KW}{TON} = \frac{12{,}000BTU/hr\ TON}{COPx3{,}517BTU/hr\ KW}$$
$Turndown\ Ratio = Maximum\ Firing\ Rate : Minimum\ Firing\ Rate\ (e.q., 5:1, 10:1, 25:1)$
$$OVERALL\ THERMAL\ EFF. = \frac{GROSS\ BTU\ OUTPUT}{GROSS\ BTU\ INPUT} x100\%$$

$$COMBUSTION\ EFF. = \frac{BTU\ INPUT - BTU\ STACK\ LOSS}{BTU\ INPUT} x100\%$$

$Overall\ Thermal\ Efficiency\ Range\ 75 - 90\%$
$Combustion\ Efficiency\ Range\ 85 - 95\%$

Electricity

$$KVA = KW + KVAR$$
$$KW_{1\varphi} = \frac{VxAxPF}{1000}$$
$$KVA_{1\varphi} = \frac{VxA}{1000}$$
$$BHP_{1\varphi} = \frac{VxAxPFxDEVICE_{EFF}}{746}$$
$$MHP_{1\varphi} = \frac{BHP_{1\varphi}}{M/D_{EFF}}$$
$$KW_{3\varphi} = \frac{\sqrt{3}xVxAxPF}{1000}$$
$$KVA_{3\varphi} = \frac{\sqrt{3}xVxA}{1000}$$
$$BHP_{3\varphi} = \frac{\sqrt{3}xVxAxPFxDEVICE_{EFF}}{746}$$
$$MHP_{3\varphi} = \frac{BHP_{3\varphi}}{M/D_{EFF}}$$

$KVA = Total\ Power\ (Kilovolt\ Amps)$
$KW = Real\ Power, Electrical\ Energy\ (Kilowatts)$
$KVAR = Reactive\ Power\ or\ "Imaginary"\ Power\ (Kilovolt\ Amps\ Reactive)$
$V = Voltage\ (Volts)$
$A = Current\ (Amps)$
$PF = Power\ Factor\ (0.75 - 0.95)$
$BHP = Break\ Horsepower$
$MHP = Motor\ Horsepower$
$EFF = Efficiency$
$M/D = Motor\ Drive$

Solar Radiation

$$q = \sum (AxSCxMSHGxCLF)$$

$$q = Cooling\ Load\ \left(\frac{BTU}{hr}\right)$$

$A = Window\ Area\ (Square\ feet)$
$SC = Shading\ Coefficient$
$MSHG = Maximum\ Solar\ Heat\ Gain\ (Btu/hr/ft^2)$
$CLF = Cooling\ Load\ Factor$

Motor Load Factor

$$KW = \frac{HP(0.746KW)(LF)}{Efficiency\ HP}$$
$$LF = Load\ Factor$$

Simple Payback Period

$$SPP = \frac{implementation\ cost}{annual\ savings}$$

Greenhouse Gas Emissions

$$GHG_E = EF_E\ x \frac{1\ KWhr\ usage}{year}\ x \frac{1\ metric\ ton}{2205\ Lb}$$

$$GHG_{NG} = EF_{NG}\ x \frac{1.03\ MMBTU}{1\ MCF}\ x \frac{1\ MCF\ usage}{year}\ x\ \frac{1\ metric\ ton}{2205\ Lb}$$

$GHG_E = Greenhouse\ gas\ emissions\ due\ to\ electric$
$GHG_{NG} = Greenhouse\ gas\ emissions\ due\ to\ natural\ gas$
$EF_E = 1.51152\ \frac{Lb.CO_2e}{KWhr} = Emission\ factor\ for\ electric$, *per EPA eGRID 9th edition, 2010, for subregionRFCW*
$EF_{NG} = 116.98\ \frac{Lb.CO_2e}{MMBTU} = Emission\ factor\ for\ natural\ gas$, *per EPA Climate Leaders GHG Inventory protocol*

Life Cycle Cost for Equipment

$$\text{LCC} = \text{Equipment Cost} + \text{Installation} + \text{Other Costs} + \text{NPV}_\text{E}\ \text{x Energy} + \text{NPV}_\text{S}\ \text{x Service} + \text{NPV}_\text{W}\ \text{x Warranty}$$

Equipment Cost	*Fist Cost of equipment through Bid or State Term or*
Other Costs	*Additional construction costs incurred due to the selected unit such as ventilation or exhaust requirements, noise abatement, floor space required, piping and wiring costs, control interface costs, foundation costs, etc.*
Energy	*Annual cost of energy usage*
Service	*Annual cost of service/maintenance agreement*
Warranty	*Annual cost of extended warranty*
NPV_E	*Net Present Value factor to bring future energy costs for the economic life of the equipment back to the present using the agreed-upon discount rate, escalation rates*
NPV_S	*Net Present Value factor to bring future service costs for the economic life of the equipment back to the present using the agreed-upon discount rate, escalation rates*
NPV_W	*Net Present Value factor to bring future extended warranty costs for the length of the warranty back to the present using the agreed-upon discount rate*

Standard Rates of Heat Gain from People

Seated at rest	400 btuh
Seated, writing	480 btuh
Seated, typing	640 btuh
Standing, light work	800 btuh
Light bench work	880 btuh
Normal walking	1040 btuh
Heavy work, lifting	1600 btuh

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