WILLDAN

City of Lawrence

Measurement & Verification Report

March 2019 through February 2020

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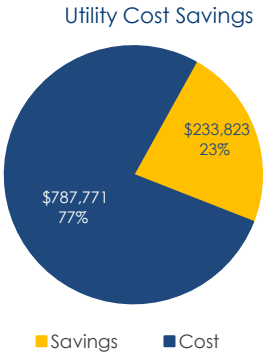
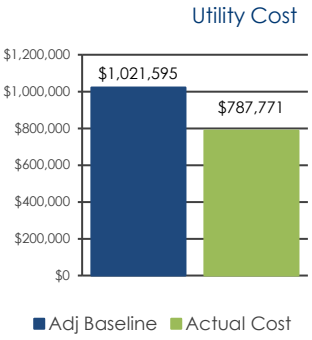
Project Summary

Willdan is pleased to provide you with this report demonstrating the level of savings achieved during the Measurement and Verification Phase from March 2019 through February 2020 as a result of the energy conservation upgrades project. As this report demonstrates, significant energy and maintenance cost savings were achieved throughout your facilities. The total of all savings during the reporting period was $543,507 which was comprised of $189,781 in Option C Electric Savings, $44,042 in Option C Fuel Savings, $170,312 in Option A Electric Savings, $11,668 in Stipulated Electric/Fuel Savings, and $127,704 in Stipulated Maintenance Savings; including a baseline adjustment of (-$2,322) as explained in Appendix. The total was -$2,190 less than the guarantee savings of $545,697.



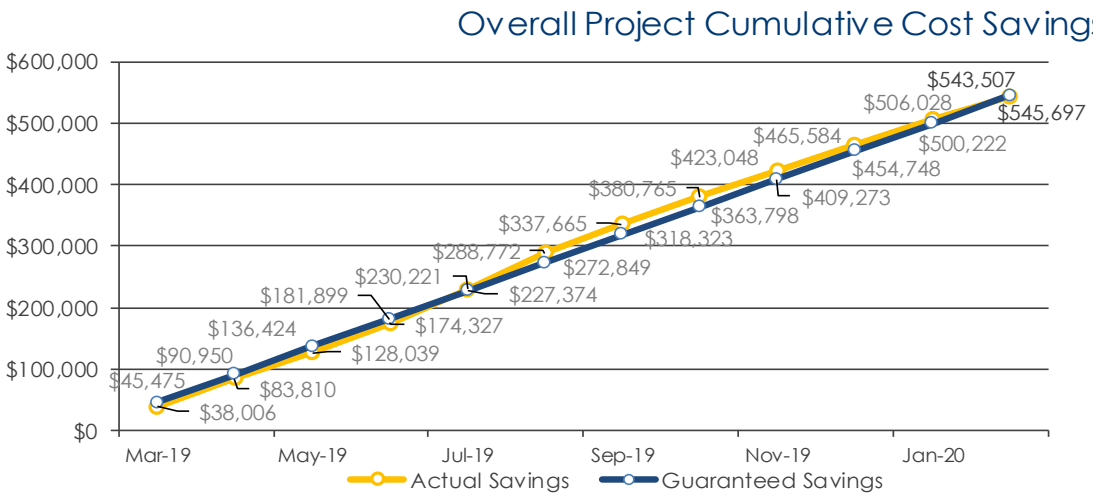
Sincerely,

Kevin Player
Measurement & Verification Professional



Project Savings Performance Summary

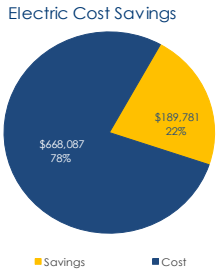
The chart below tracks project savings over time. The blue line represents the guaranteed contract savings while the yellow line represents the actual savings achieved.

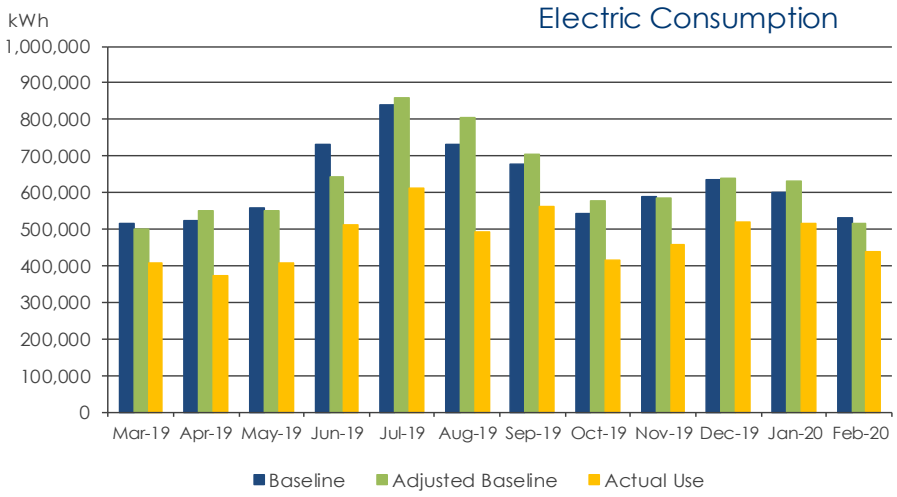


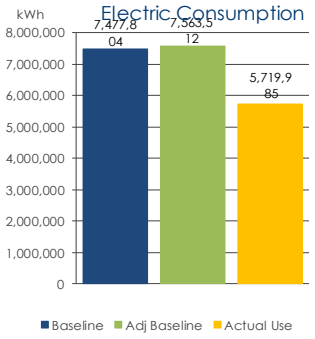
Savings Details

Overall Electrical Performance

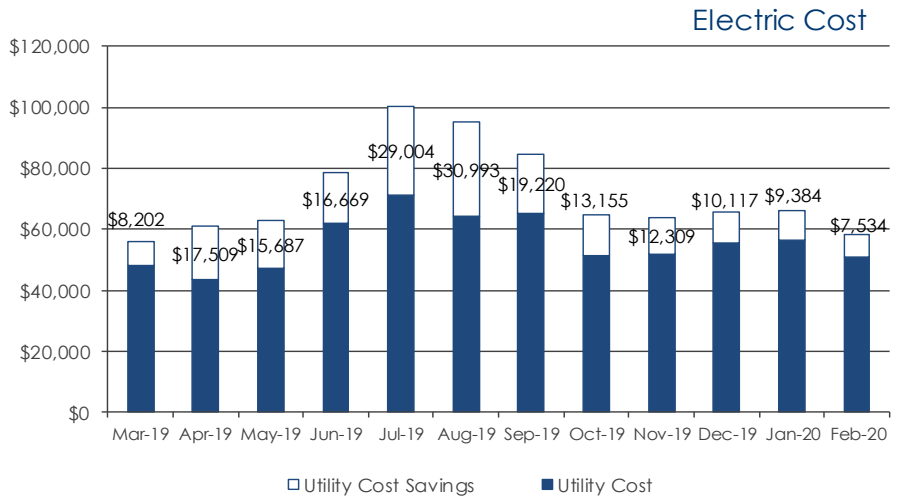
The following graphs illustrate the electrical performance for all facilities during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

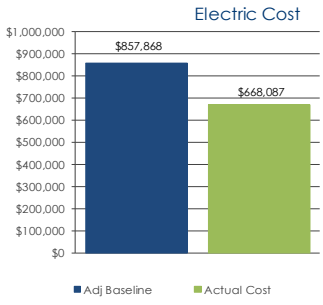




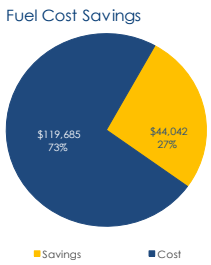


The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.





Overall Fuel Performance



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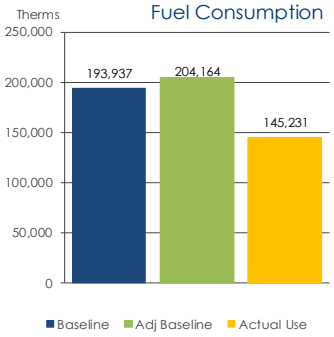

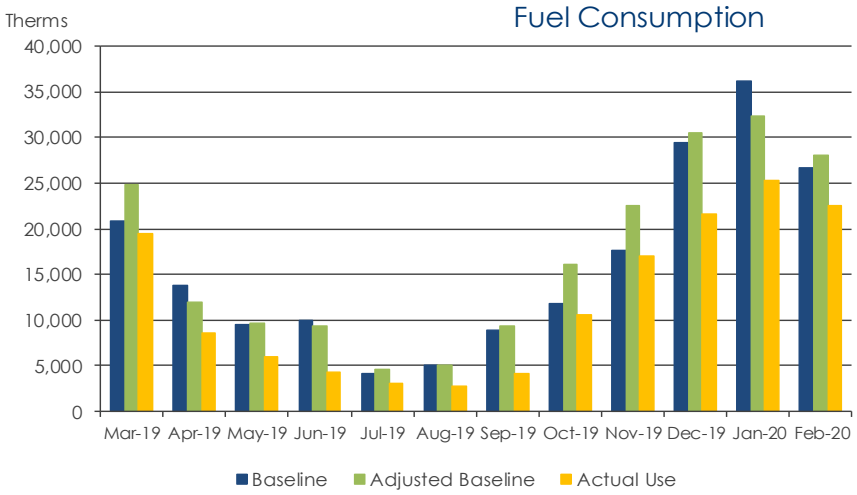

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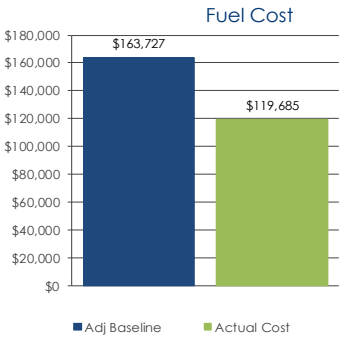
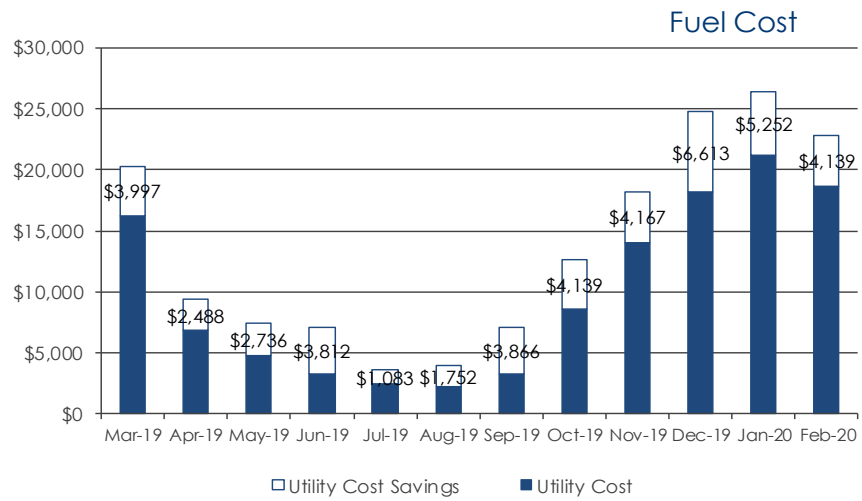
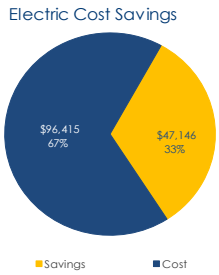
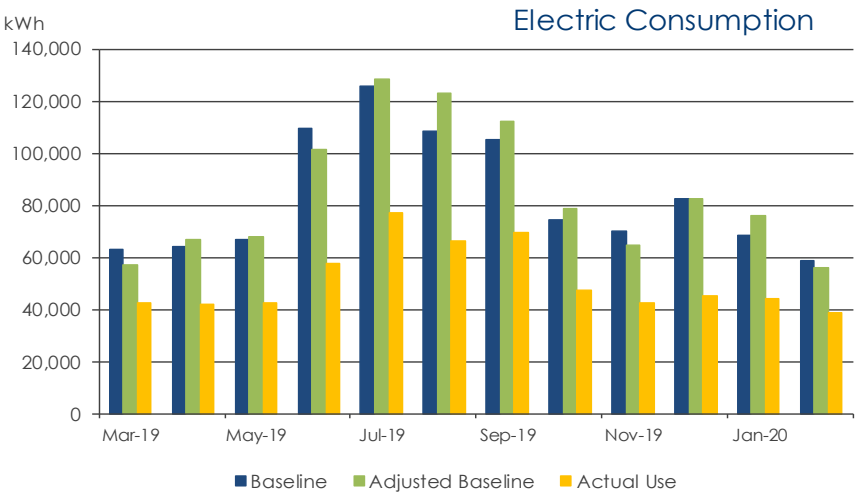


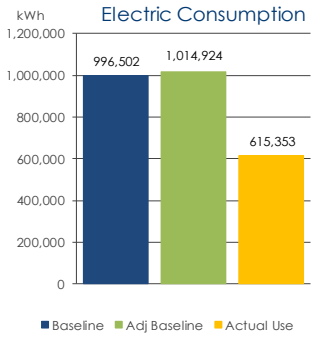


Community Health Building Electrical Performance

The following graphs illustrate the electrical performance for the Community Health Building during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.







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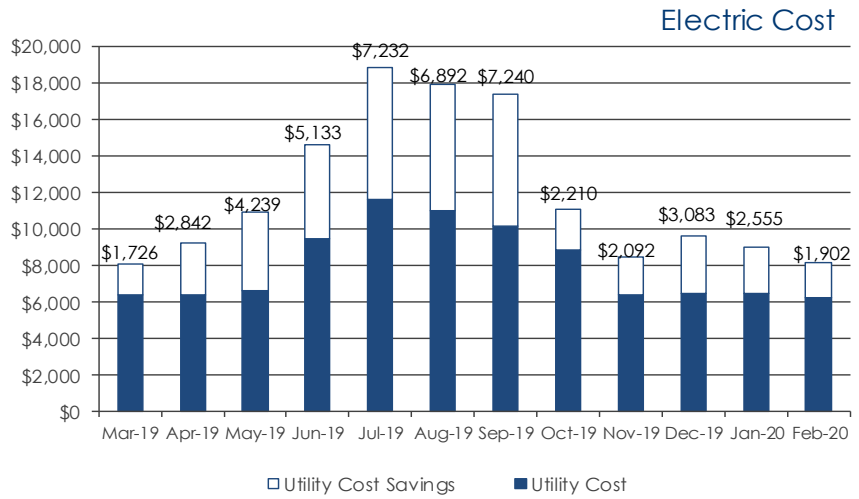
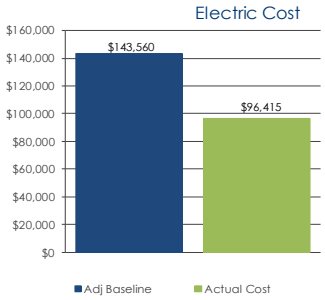
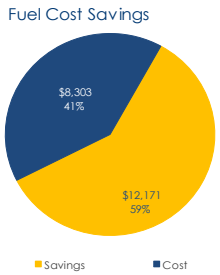


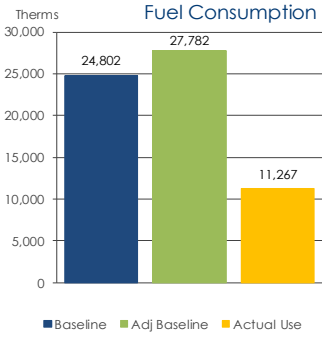


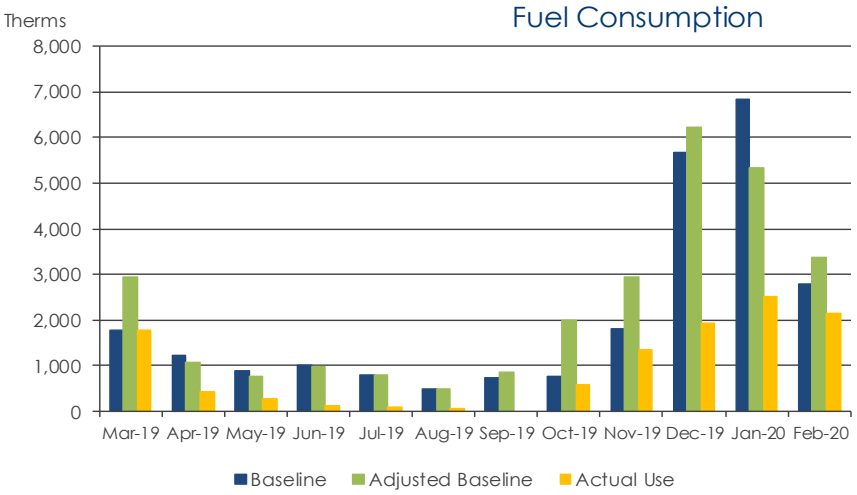
Facility Improvements:
* New Air-cooled chiller,
* New Air handler filtration,
* New DDC controls with updated sequences,
* New roof,
* New LED lighting

Community Health Building Fuel Performance



The following graphs illustrate the fuel performance for the Community Health Building during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





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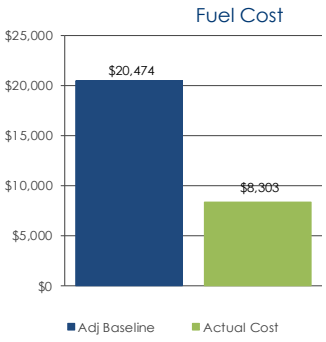
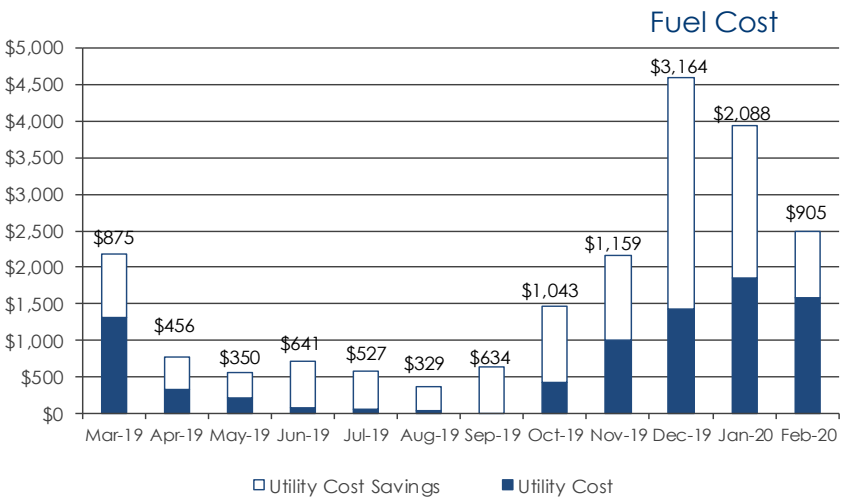
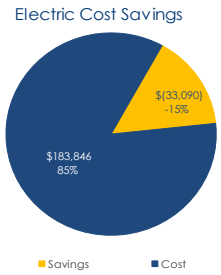


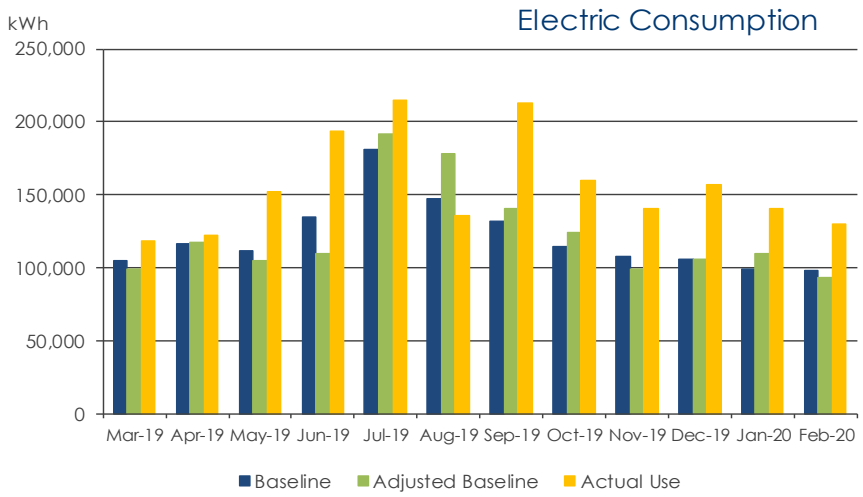


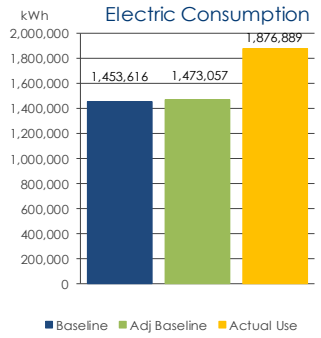
Facility Improvements:
* New heating water boilers,
* New Air handler filtration,
* New DDC controls with updated sequences,
* New roof

Indoor Aquatic Center Electrical Performance

The following graphs illustrate the electrical performance for the Indoor Aquatic Center during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.







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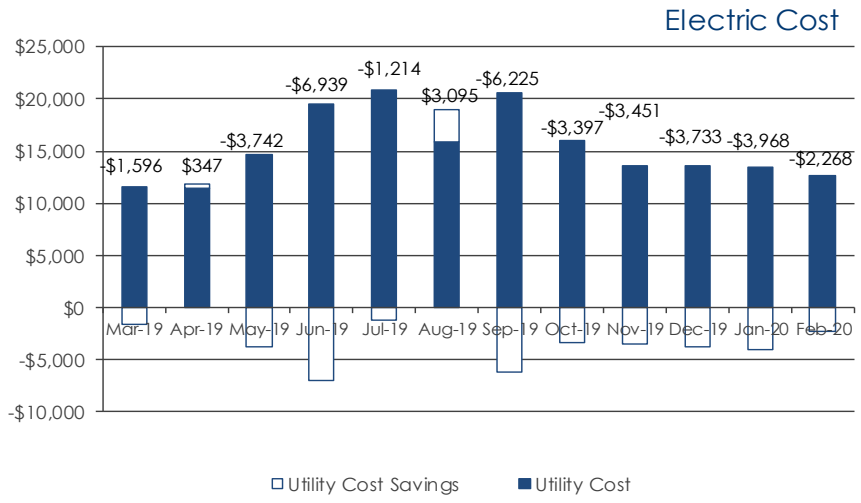
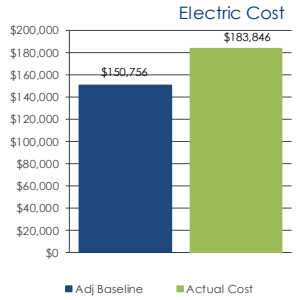
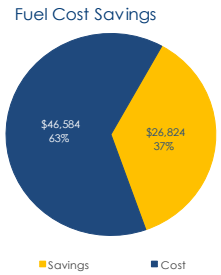


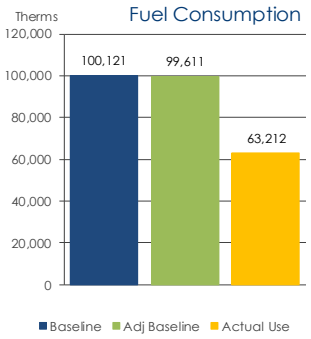


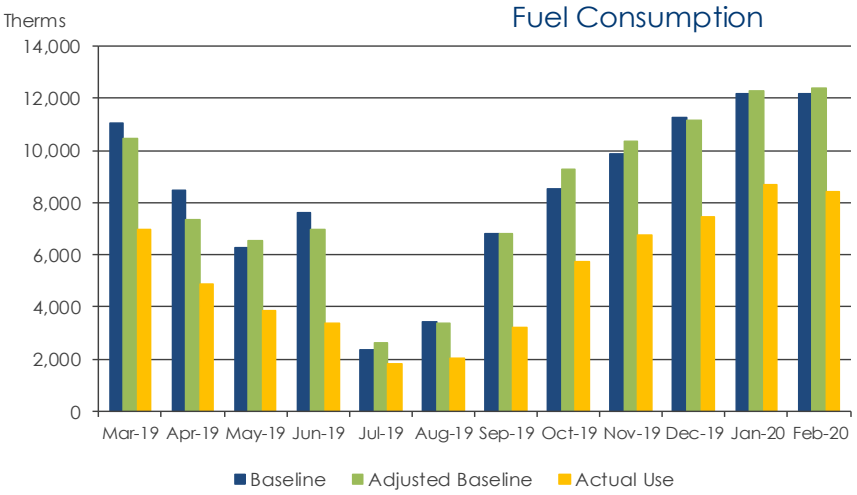
Facility Improvements:
* 2 New dehumidification units,
* New low-capture exhaust systems,
* New pool pump variable frequency drives,
* New VAV air handler condensing unit,
* New supplemental electric heat,
* Updated sequences,
* LED lighting

Indoor Aquatic Center Fuel Performance



The following graphs illustrate the fuel performance for the Indoor Aquatic Center during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





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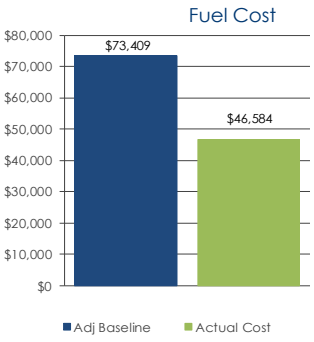
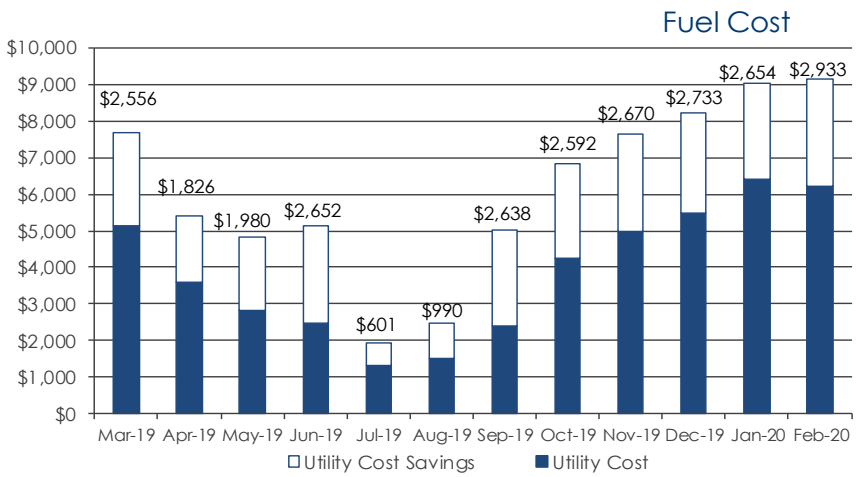
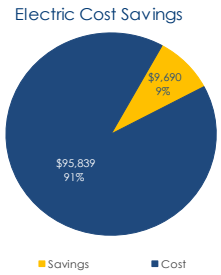


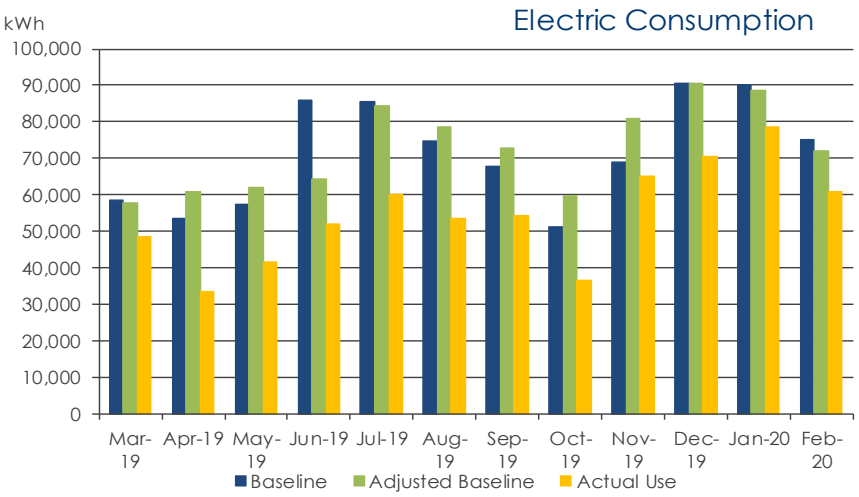


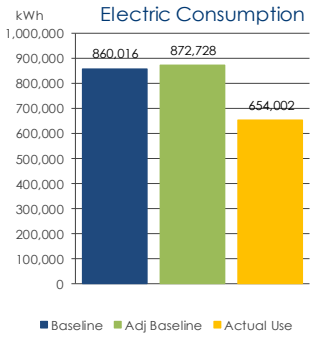
Facility Improvements:
* 2 New dehumidification units,
* New pool heating boilers,
* New pool pump variable frequency drives,
* Updated sequences

Library Electrical Performance

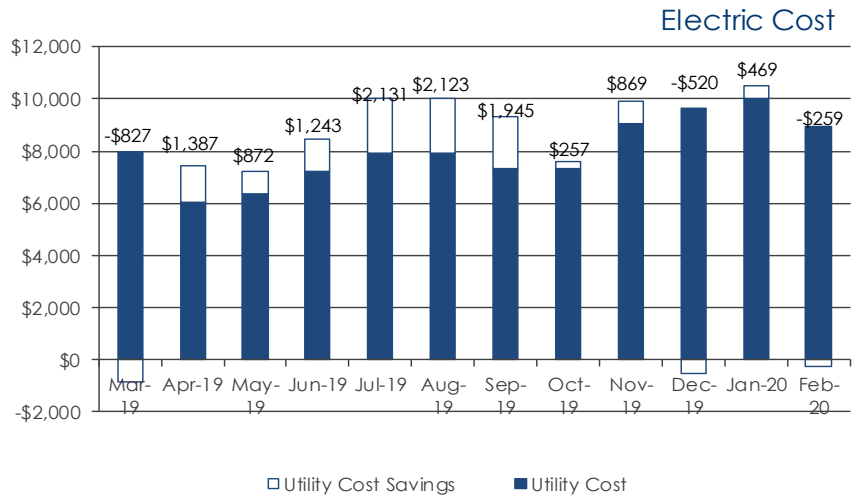
The following graphs illustrate the electrical performance for the Library during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

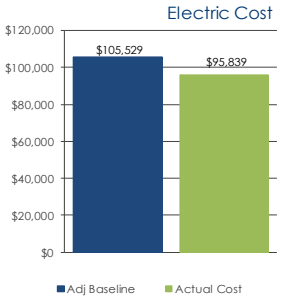






The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

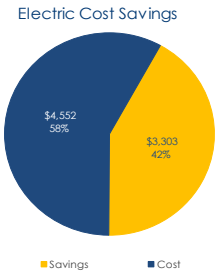


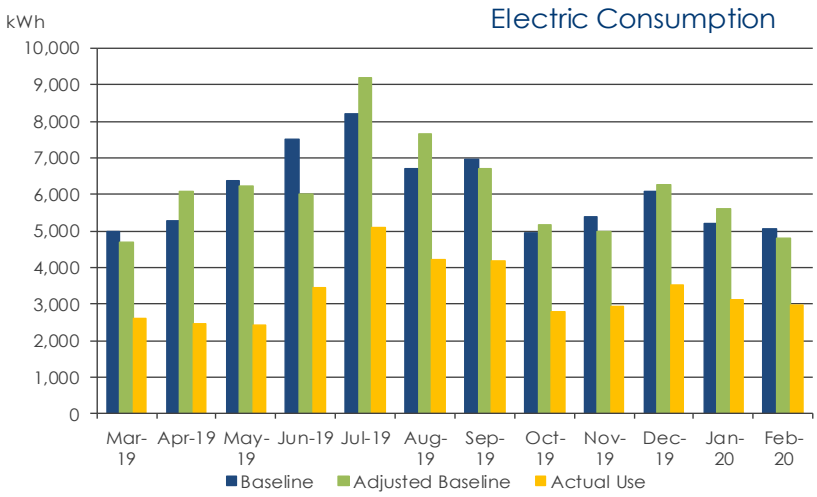


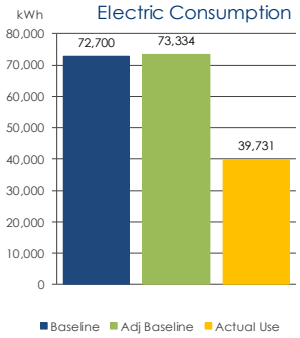
Facility Improvements:
* New CO2 sensors & updated sequences for demand controlled ventilation,
* LED lighting

Airport Terminal Electrical Performance

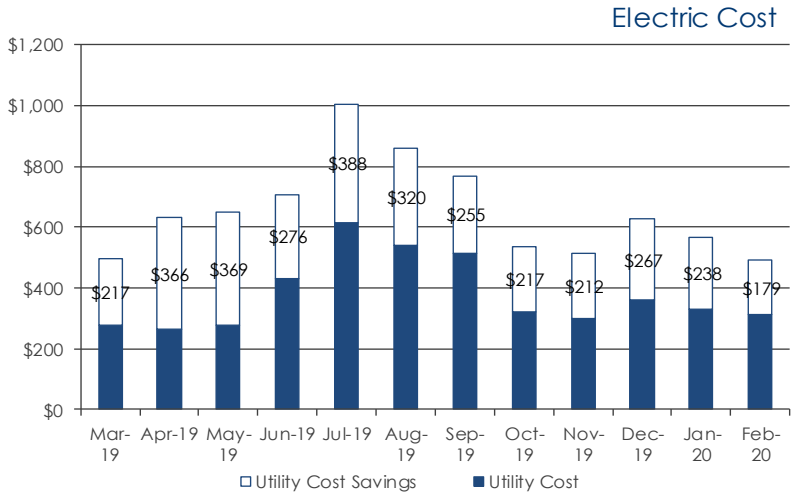
The following graphs illustrate the electrical performance for the Airport Terminal during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

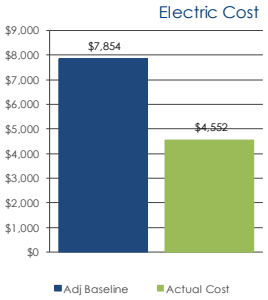






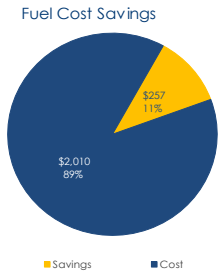
The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



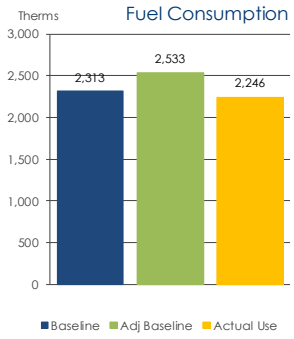


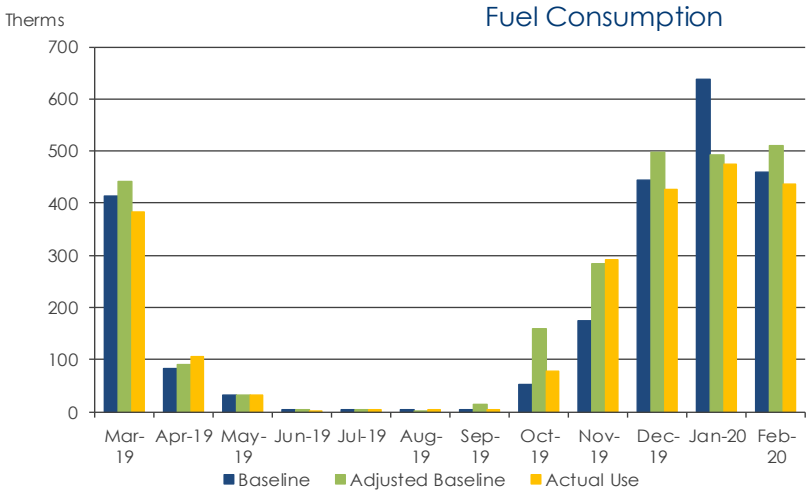
Facility Improvements:
* New AC split systems,
* New internet-based thermostats,
* LED lighting

Airport Terminal Fuel Performance

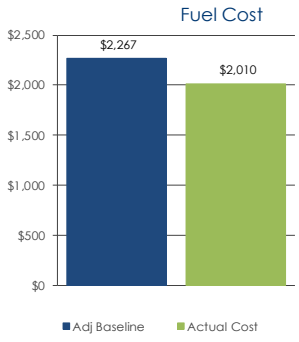


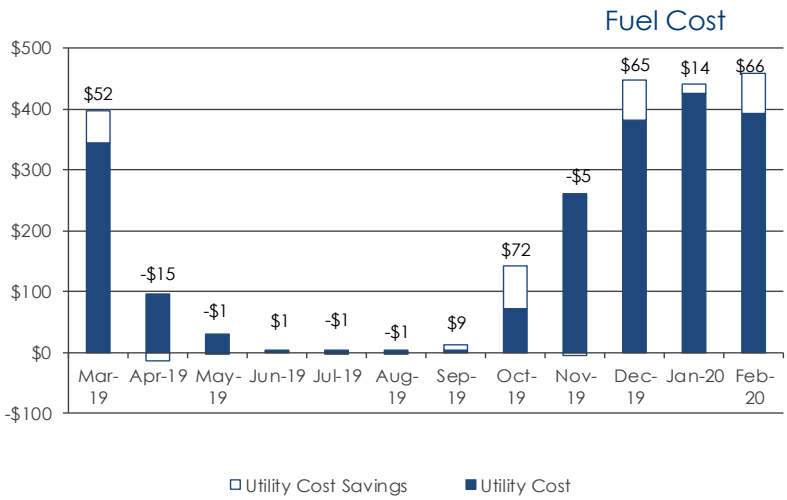
The following graphs illustrate the fuel performance for the Airport Terminal during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

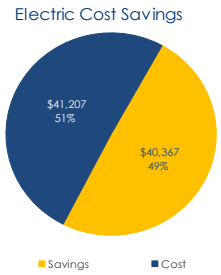


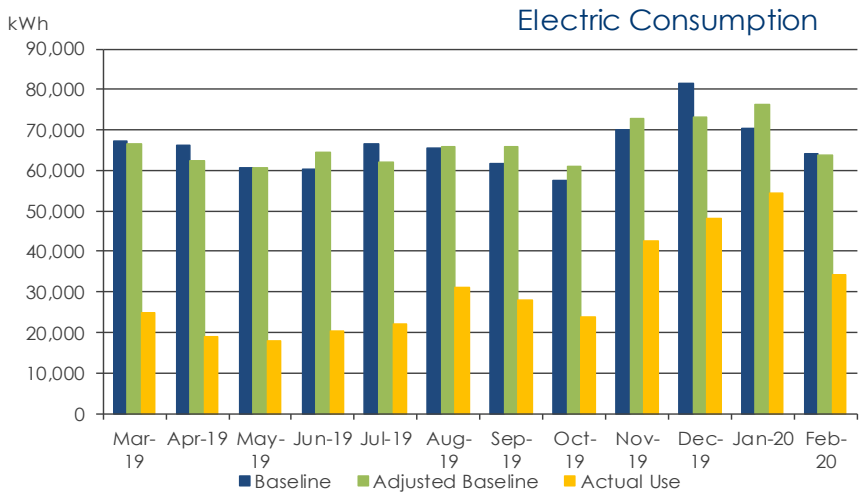


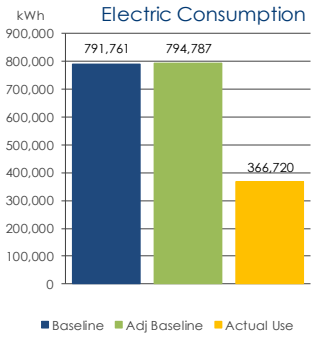
Facility Improvements:
* New gas furnaces,
* New internet-based thermostats

Fire/Med #5 Electrical Performance

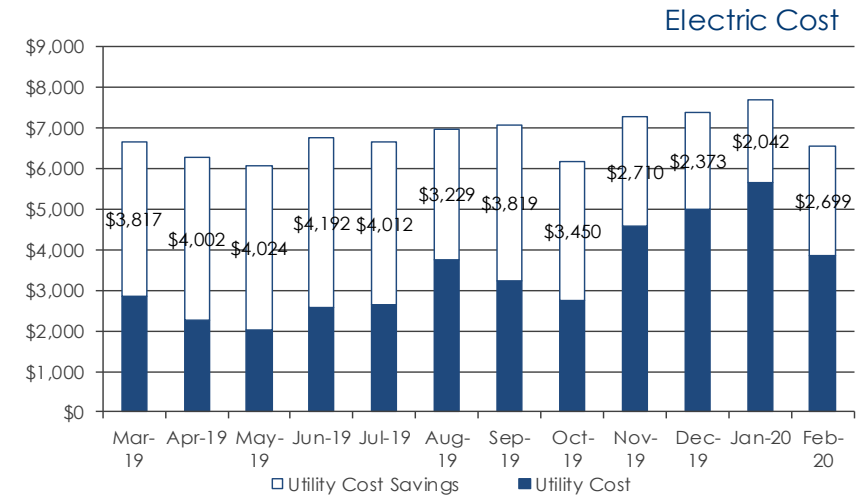
The following graphs illustrate the electrical performance for the Fire/Med #5 during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

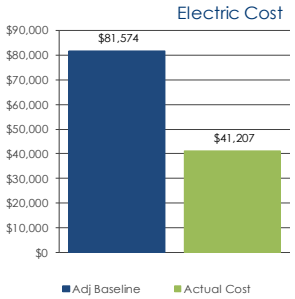






The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

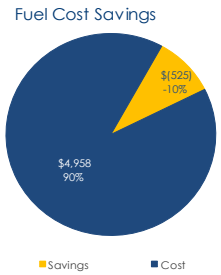




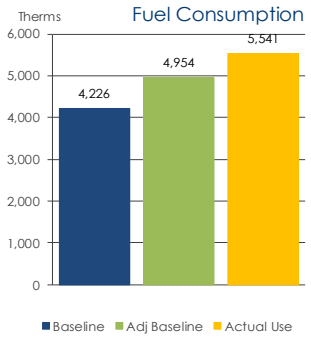
Facility Improvements:
* New 100 kW solar PV array,
* New DDC control system with updated sequences,
* LED lighting

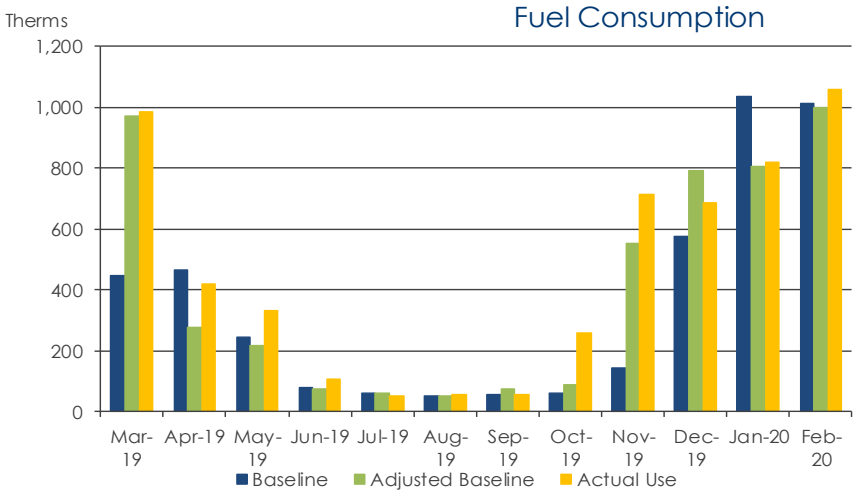
Bonus Improvements:
* Rebalance register airflows to improve comfort

Fire/Med #5 Fuel Performance

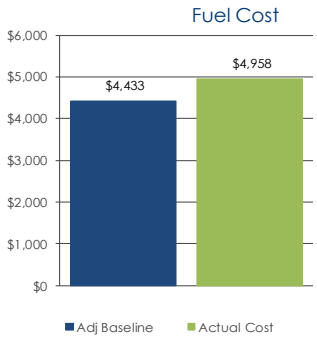


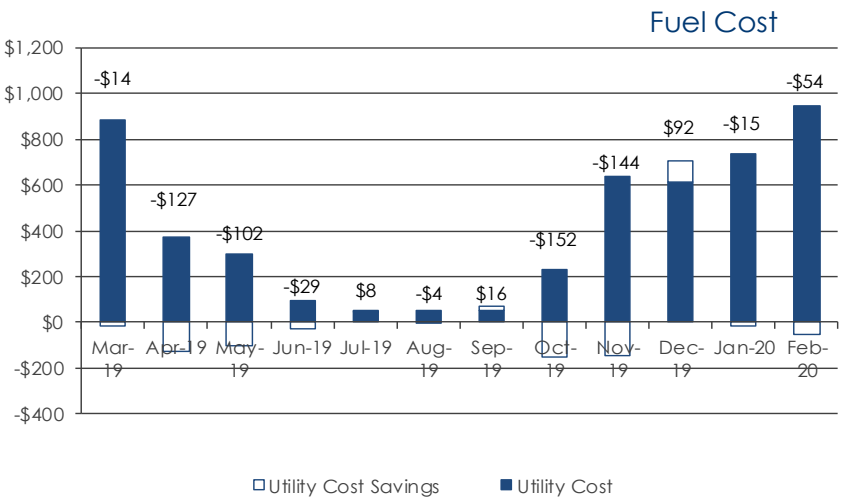
The following graphs illustrate the fuel performance for the Fire/Med #5 during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



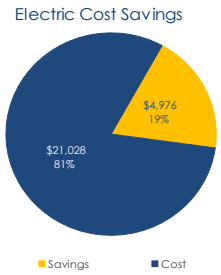


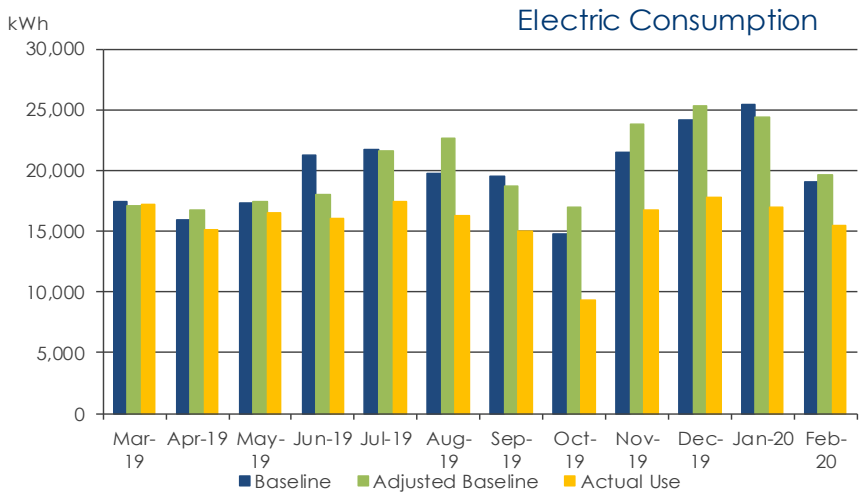
Facility Improvements:
* New DDC control system with updated sequences

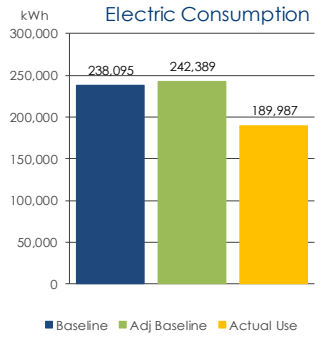
Bonus Improvements:
* Rebalance airflows to improve comfort

Fire/Med #4 Electrical Performance

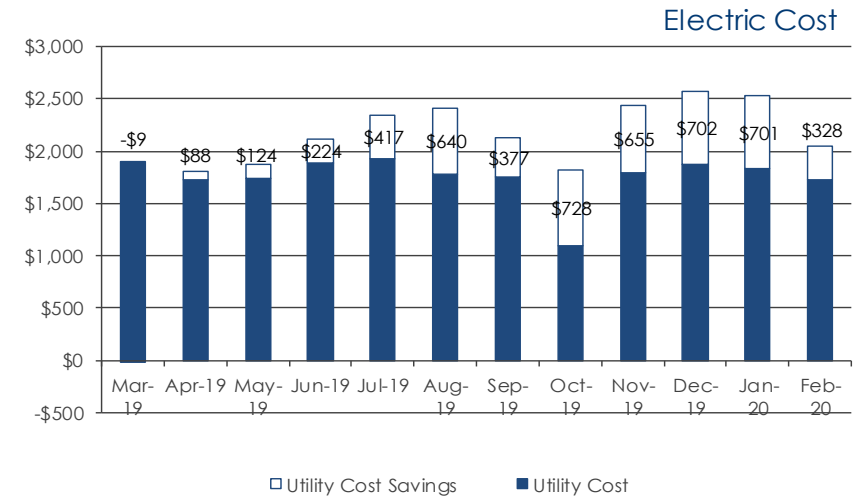
The following graphs illustrate the electrical performance for the Fire/Med #4 during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

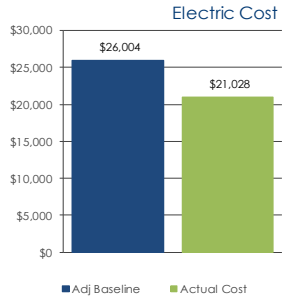






The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

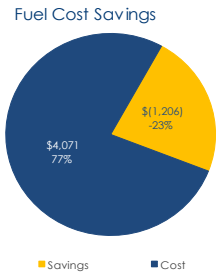




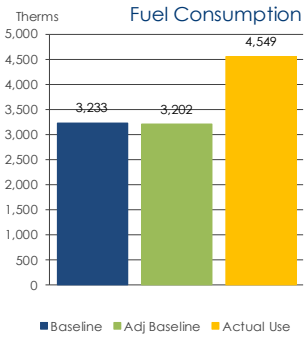
Facility Improvements:
* New DDC control system with updated sequences,
* LED lighting

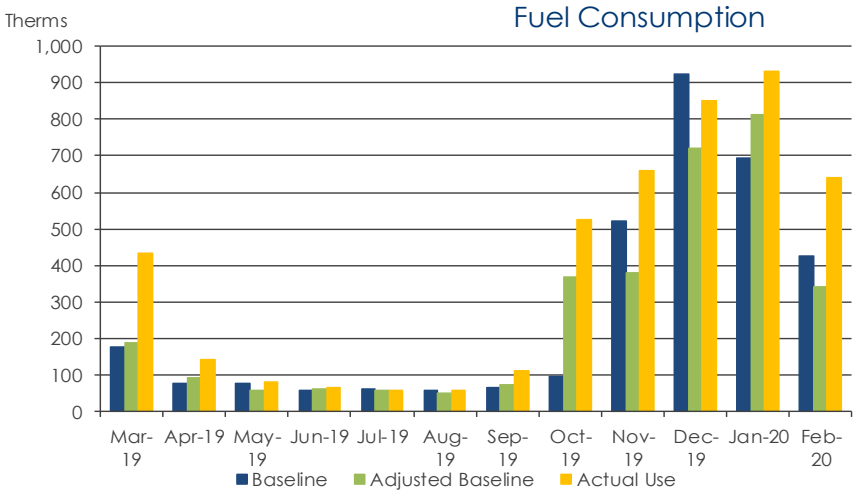
Bonus Improvements:
* Rebalance airflows to improve comfort

Fire/Med #4 Fuel Performance

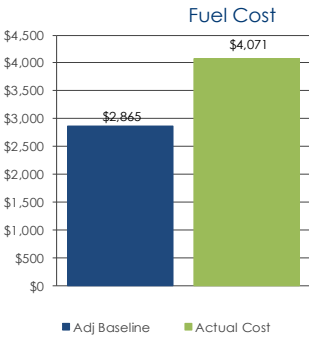


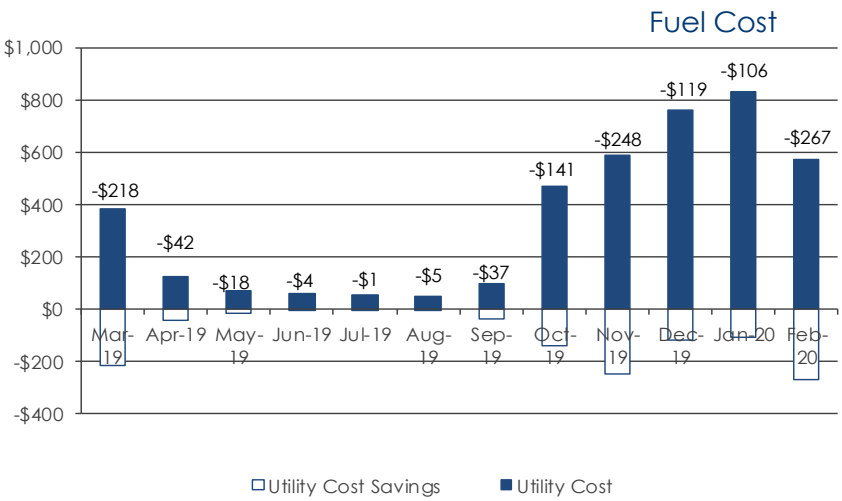
The following graphs illustrate the fuel performance for the Fire/Med #4 during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



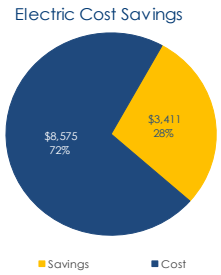


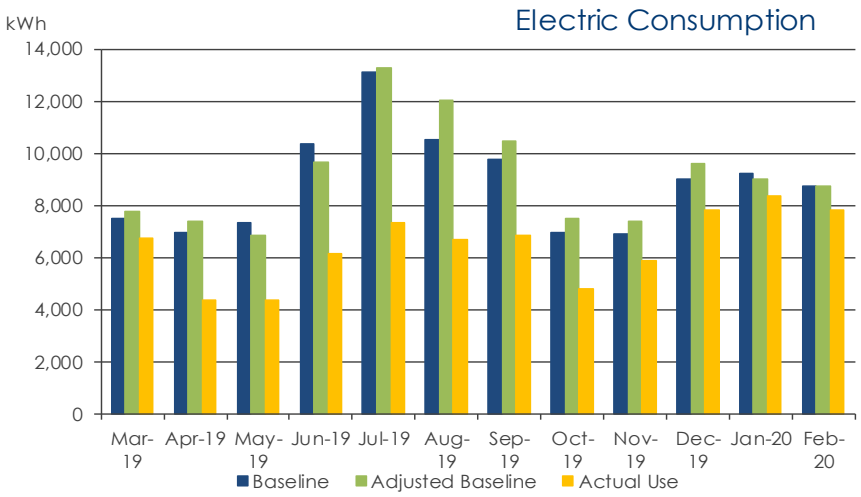
Facility Improvements:
* New DDC control system with updated sequences

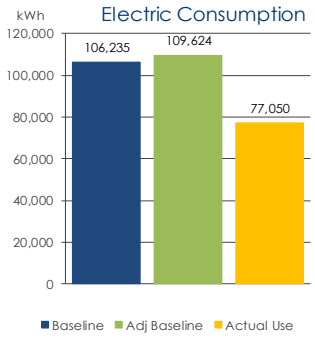
Bonus Improvements:
* Rebalance airflows to improve comfort

Fire/Med #3 Electrical Performance

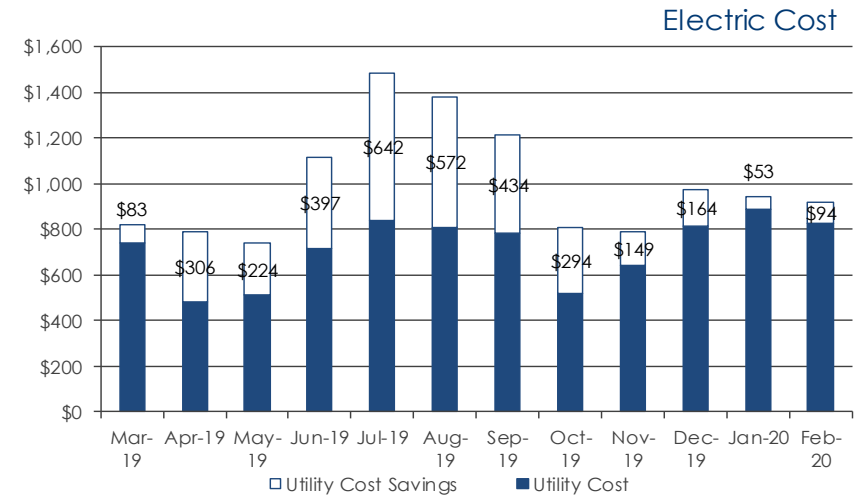
The following graphs illustrate the electrical performance for the Fire/Med #3 during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

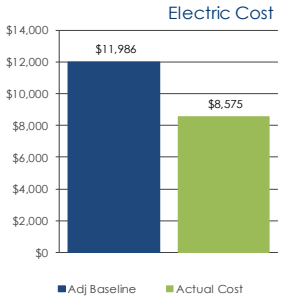






The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

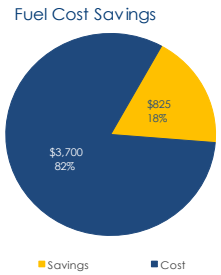




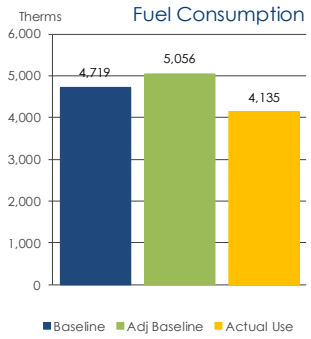
Facility Improvements:
* New packaged heating & cooling roof-top units,
* New DDC control system with updated sequences,
* New roof,
* LED lighting

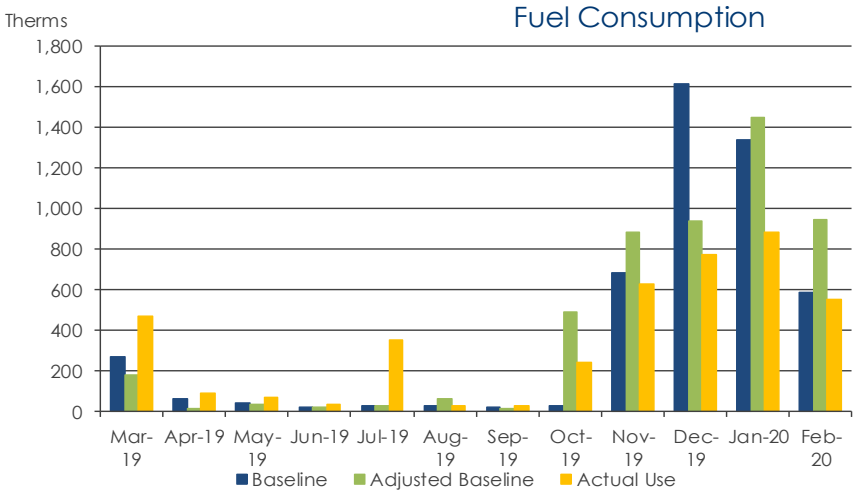
Bonus Improvements:
* Rebalance airflows to improve comfort

Fire/Med #3 Fuel Performance

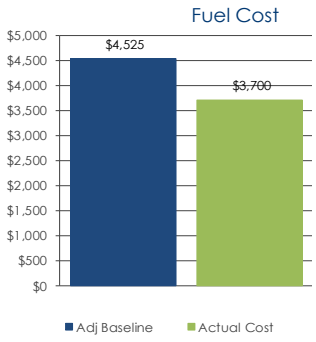


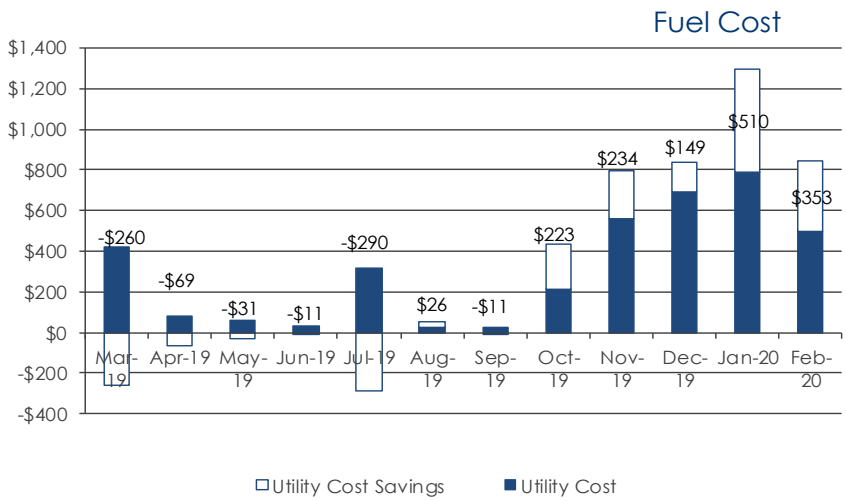
The following graphs illustrate the fuel performance for the Fire/Med #3 during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



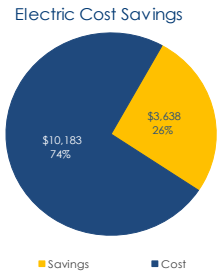


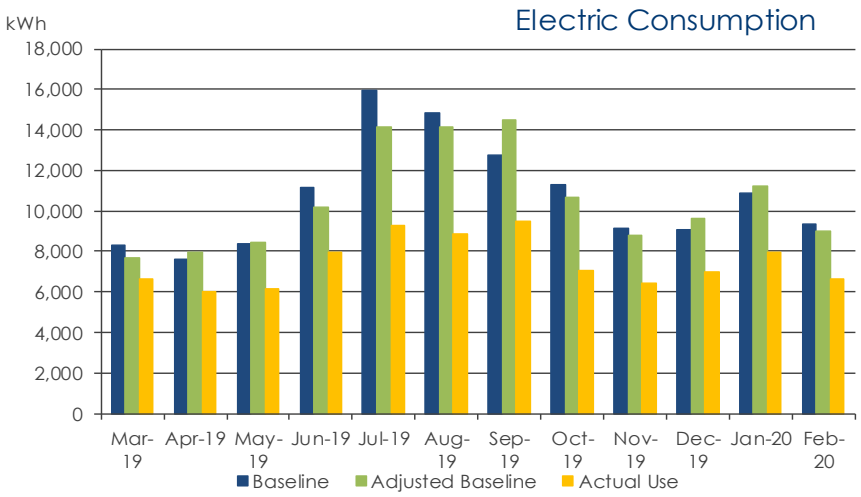
Facility Improvements:
* New packaged heating & cooling roof-top units,
* New DDC control system with updated sequences,
* New roof

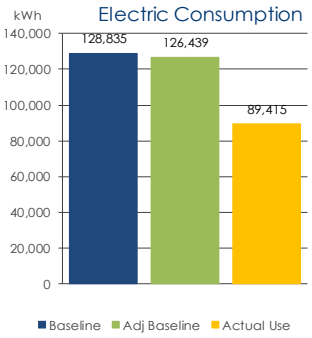
Bonus Improvements:
* Rebalance airflows to improve comfort

Fire/Med #2 Electrical Performance

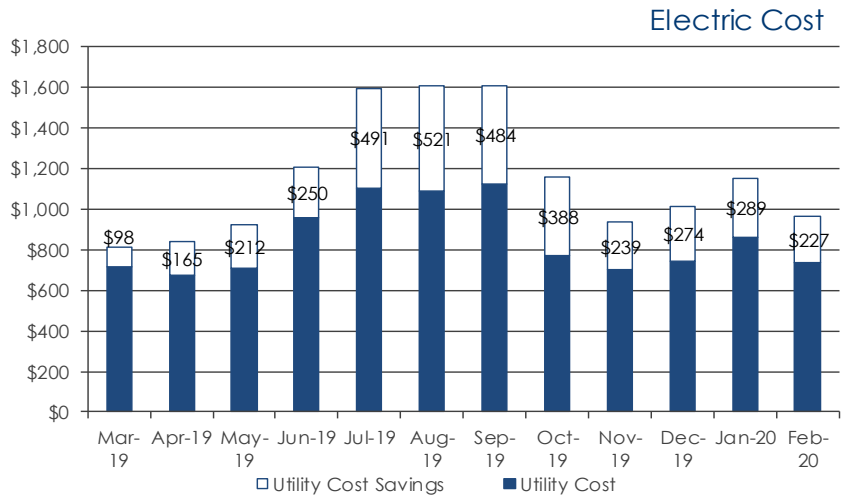
The following graphs illustrate the electrical performance for the Fire/Med #2 during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

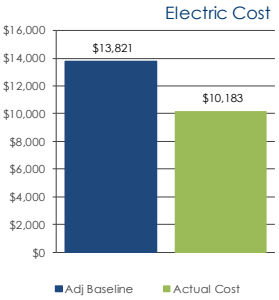






The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

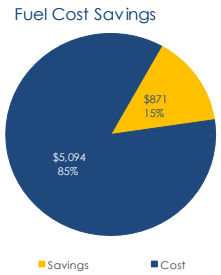




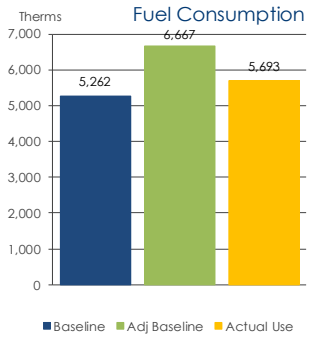
Facility Improvements:
* New packaged heating & cooling roof-top units,
* New internet-based thermostats,
* LED lighting

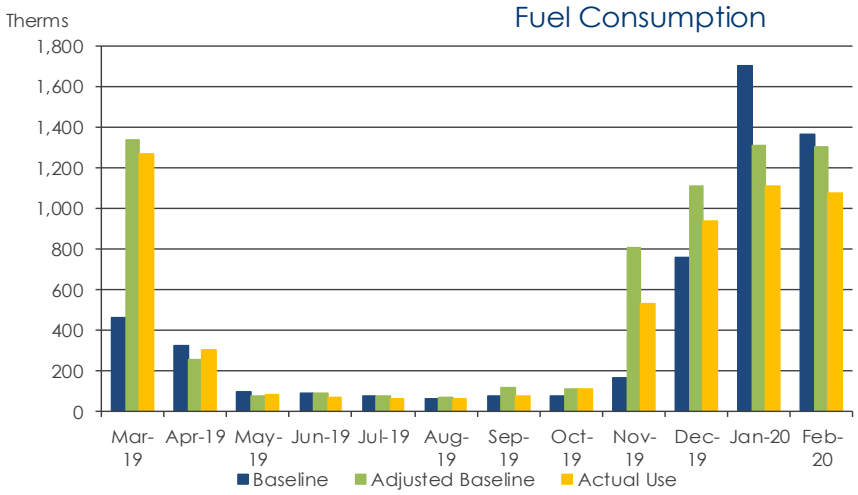
Bonus Improvements:
* Rebalance airflows to improve comfort

Fire/Med #2 Fuel Performance

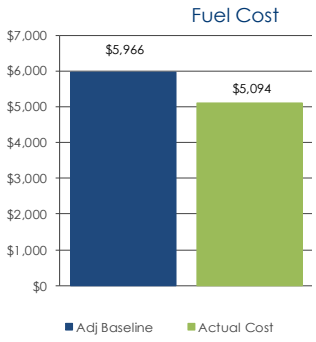


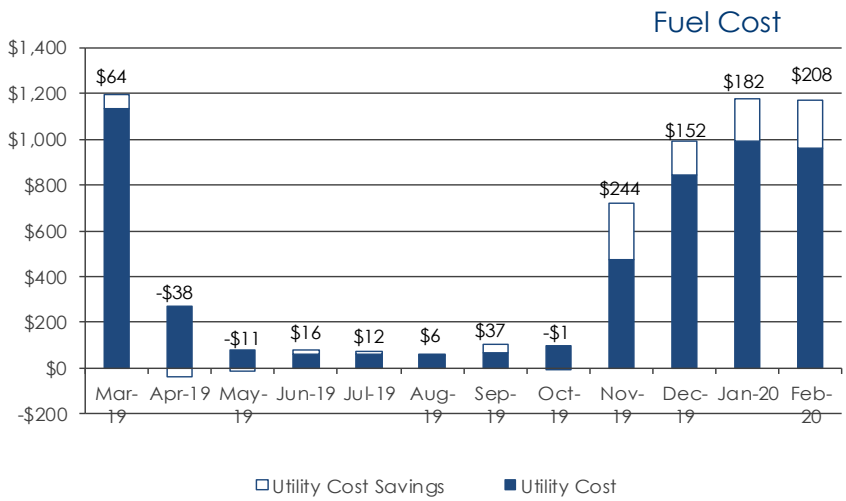
The following graphs illustrate the fuel performance for the Fire/Med #2 during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



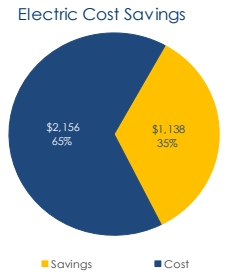


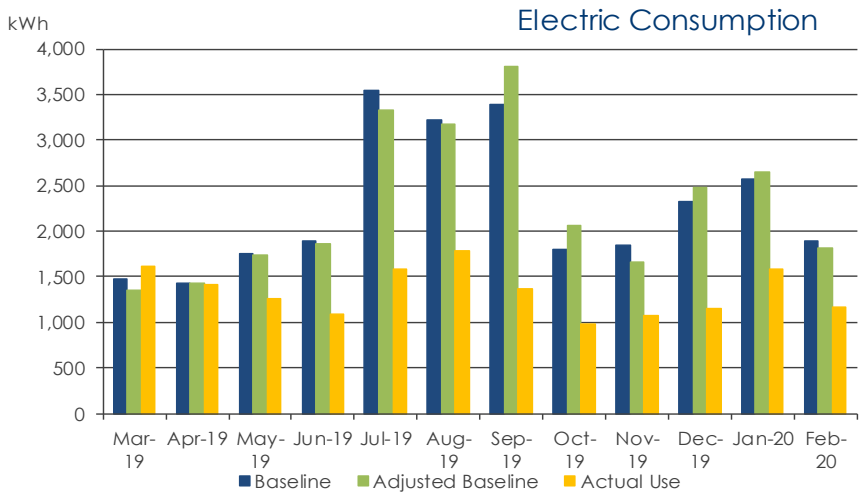
Facility Improvements:
* New packaged heating & cooling roof-top units,
* New internet-based thermostats

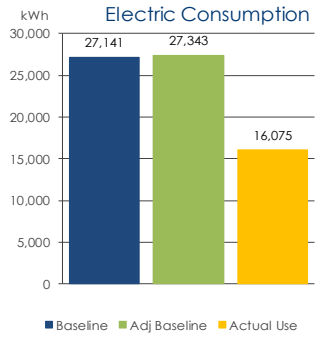
Bonus Improvements:
* Rebalance airflows to improve comfort

Fire and Rescue Training Electrical Performance

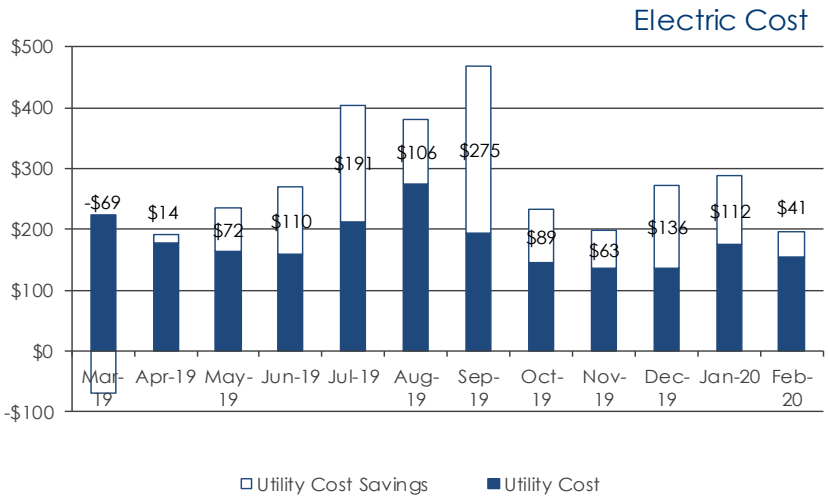
The following graphs illustrate the electrical performance for the Fire and Rescue Training during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

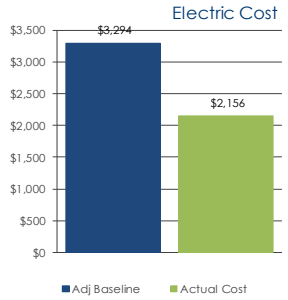






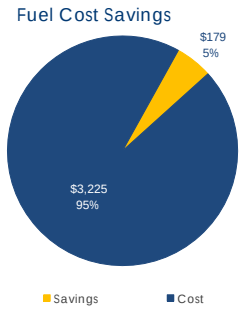
The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



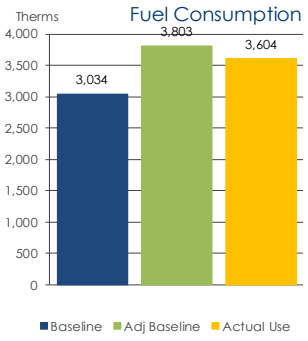


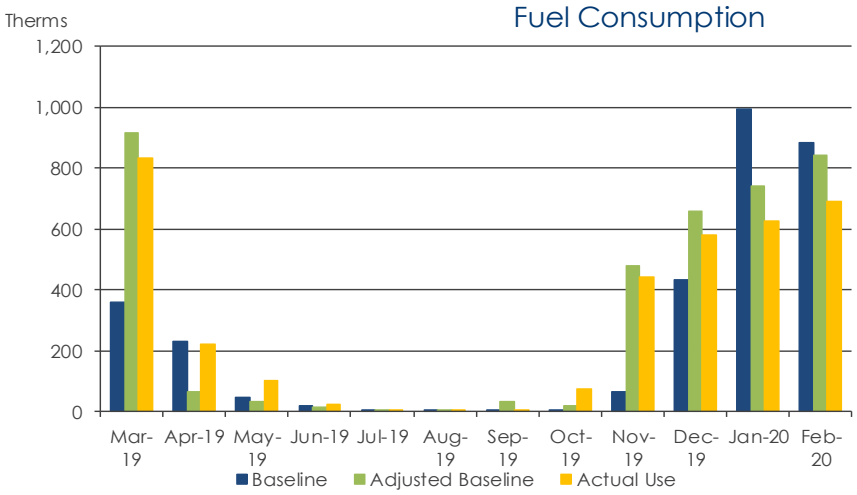
Facility Improvements:
* New internet-based thermostats
* LED lighting

Fire and Rescue Training Fuel Performance

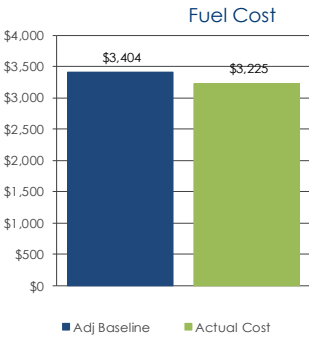


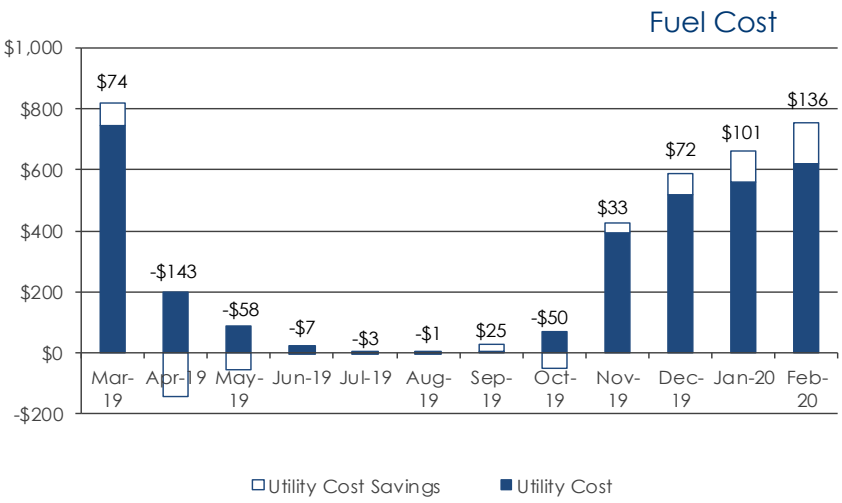
The following graphs illustrate the fuel performance for the Fire and Rescue Training during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

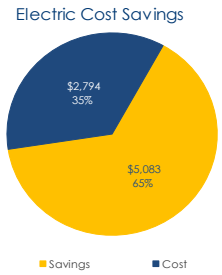


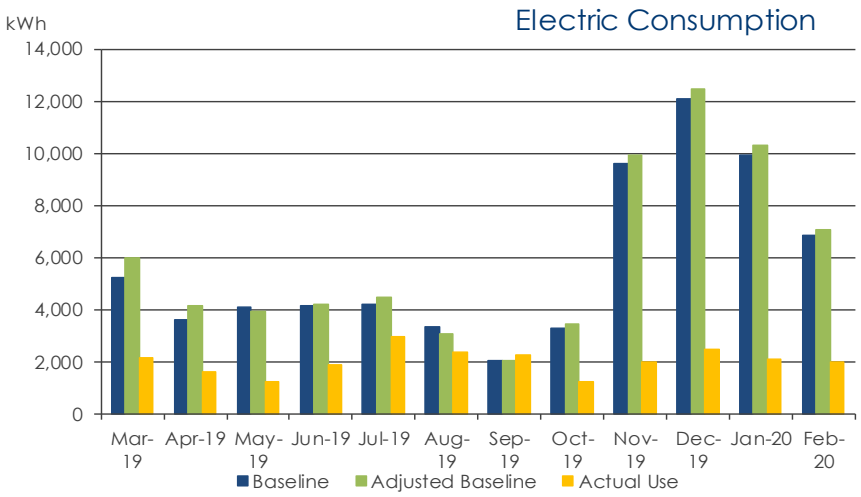


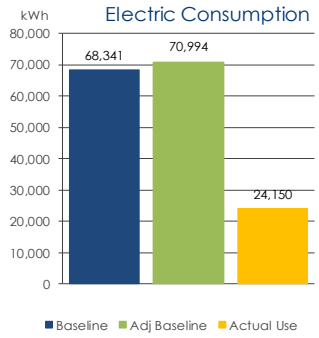
Facility Improvements:
* New internet-based thermostats

Parking/Animal Control/Transit Electrical Performance

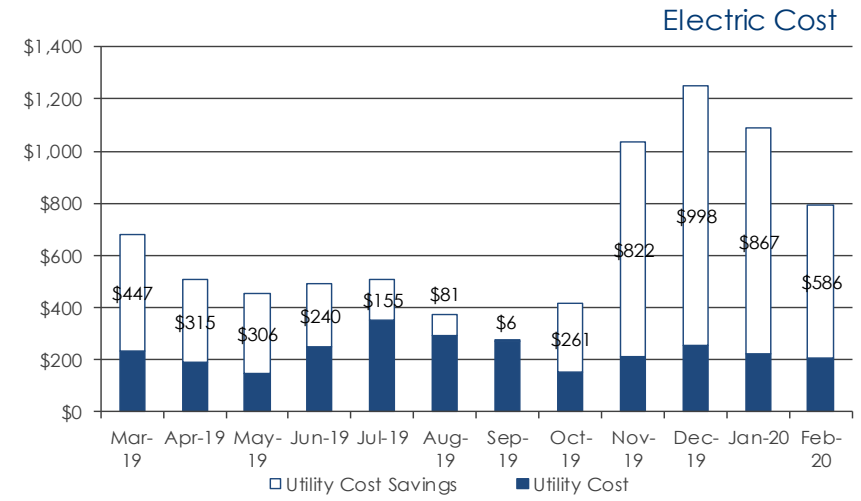
The following graphs illustrate the electrical performance for the Parking/Animal Control/Transit during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

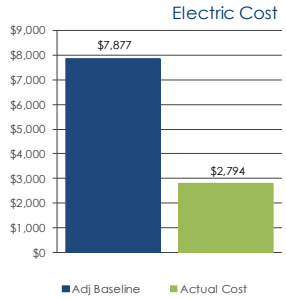






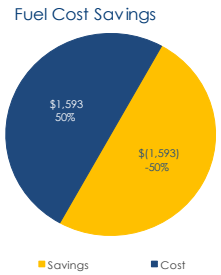
The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



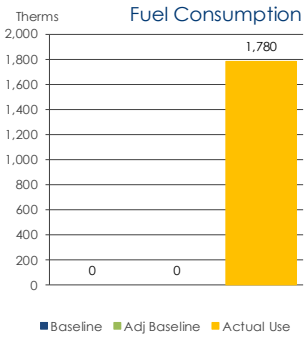


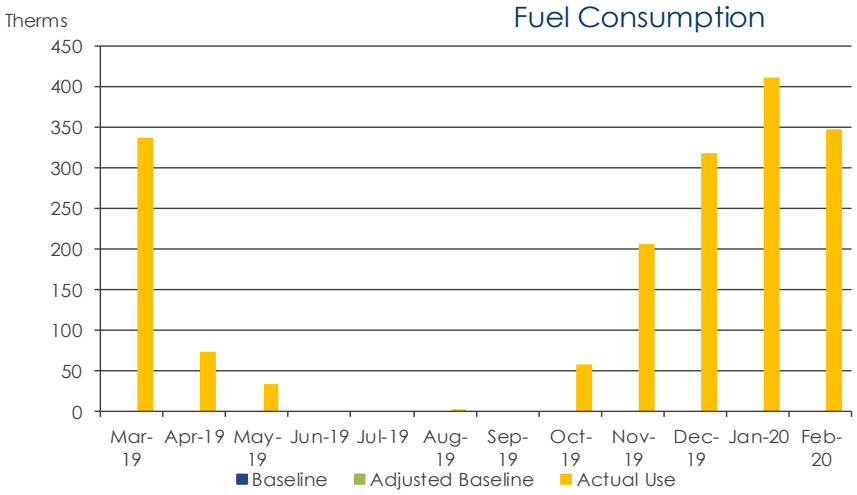
Facility Improvements:
* New packaged heating & cooling units (replaced electric heat with gas heat),
* New internet-based thermostats,
* LED lighting

Parking/Animal Control/Transit Fuel Performance

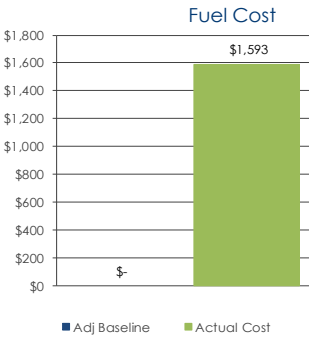


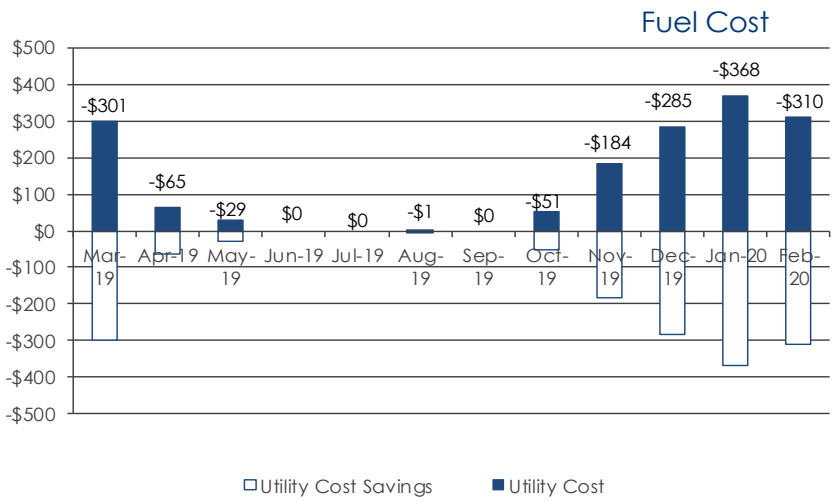
The following graphs illustrate the fuel performance for the Parking/Animal Control/Transit during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

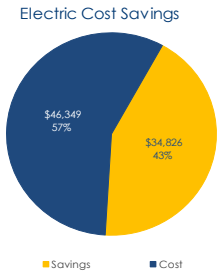


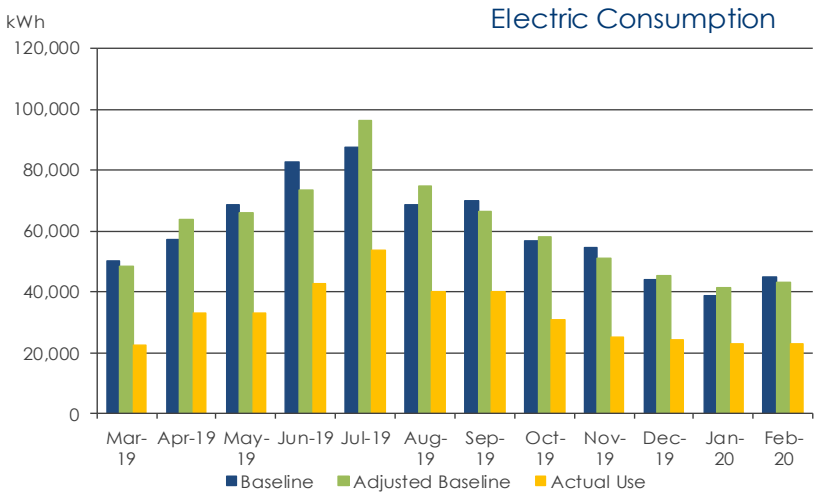


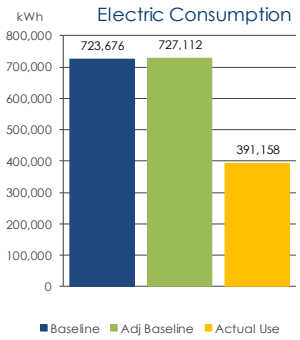
Facility Improvements:
* New packaged heating & cooling units (replaced electric heat with gas heat),
* New internet-based thermostats

Lawrence Arts Center Electrical Performance

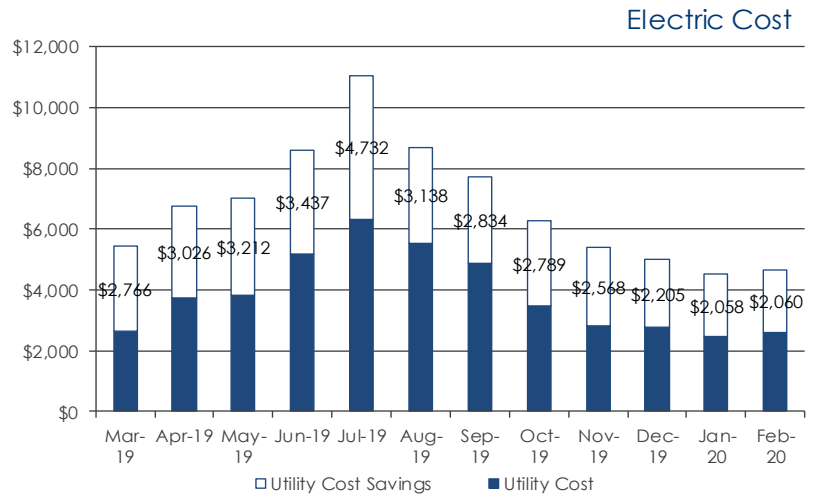
The following graphs illustrate the electrical performance for the Lawrence Arts Center during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

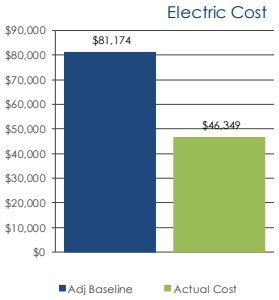






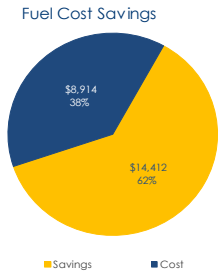
The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



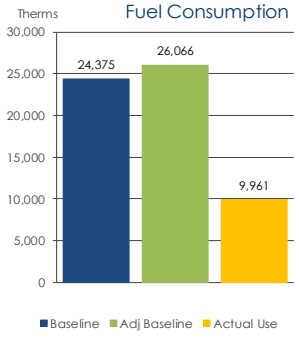


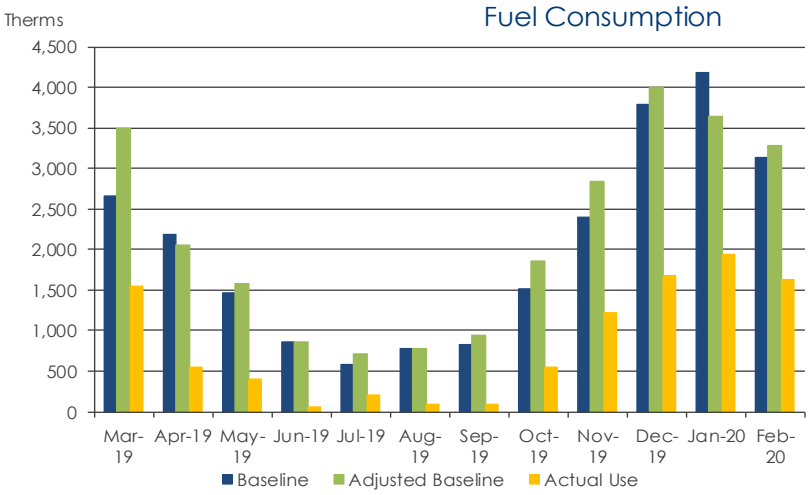
Facility Improvements:
* New air-cooled chiller,
* New DDC control system with updated sequences,
* LED lighting (except theatre performance lights)

Lawrence Arts Center Fuel Performance

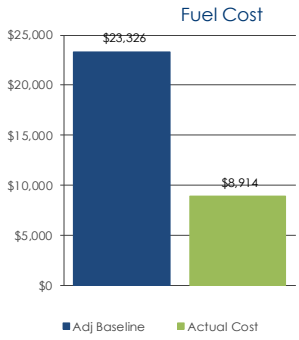


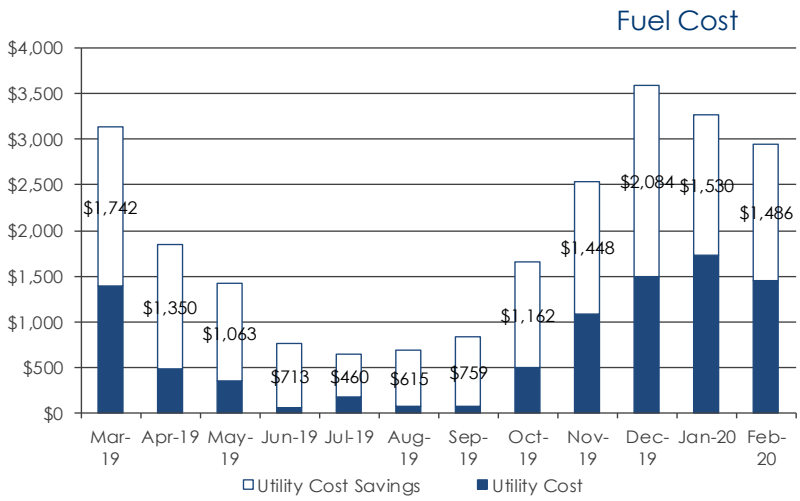
The following graphs illustrate the fuel performance for the Lawrence Arts Center during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

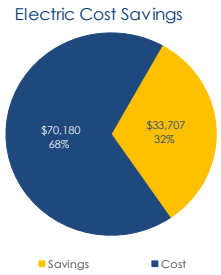


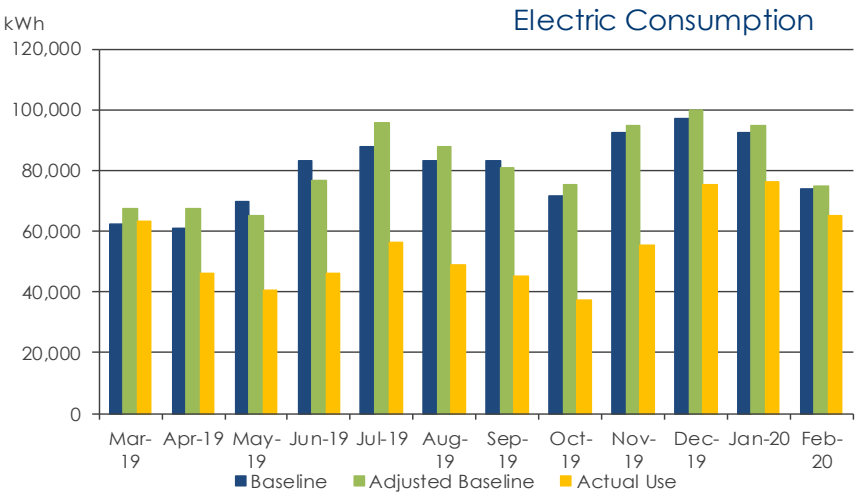


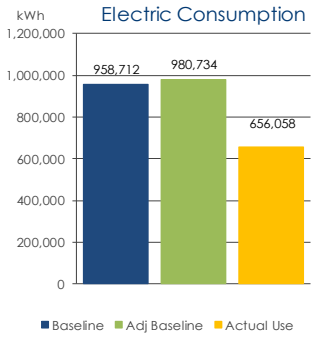
Facility Improvements:
* New DDC controls with updated sequences

City Hall Electrical Performance

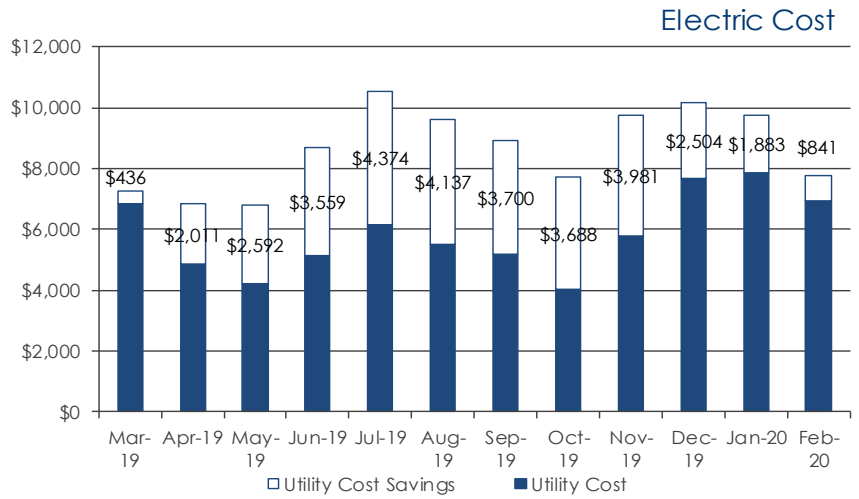
The following graphs illustrate the electrical performance for the City Hall during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

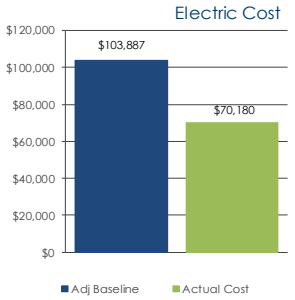






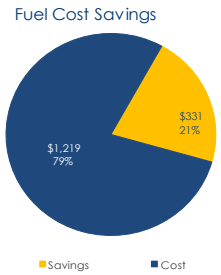
The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



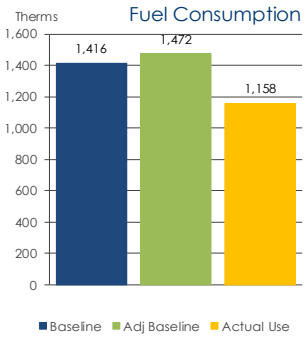


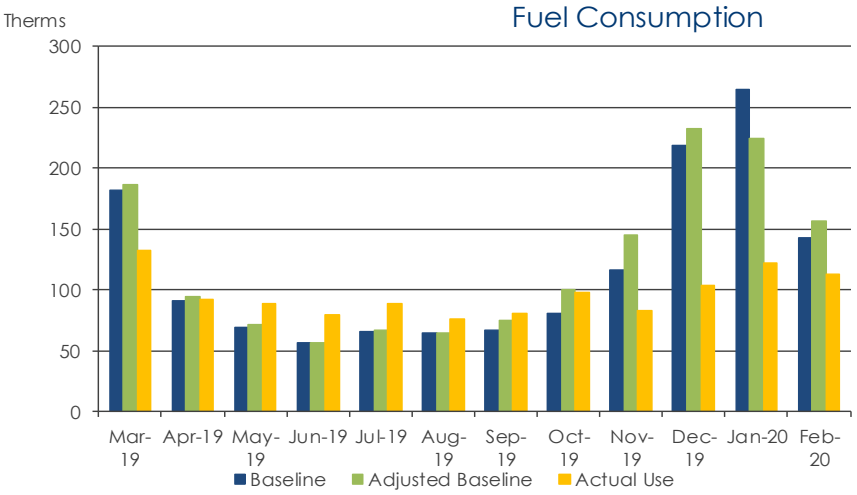
Facility Improvements:
* New supplemental electric heating in entries,
* Updated control sequences,
* New windows,
* LED lighting

City Hall Fuel Performance

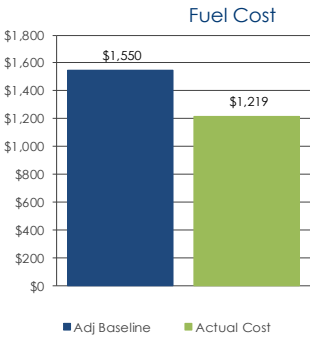


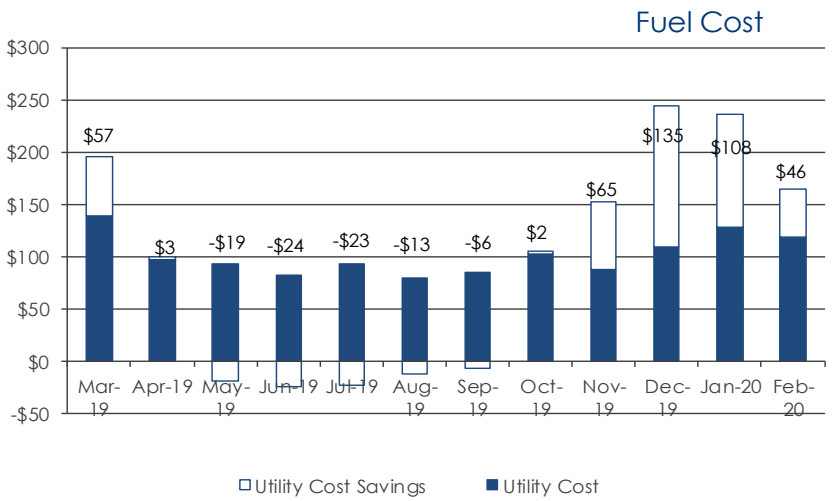
The following graphs illustrate the fuel performance for the City Hall during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

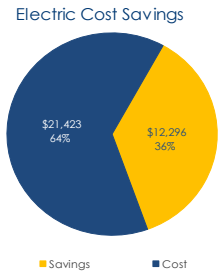


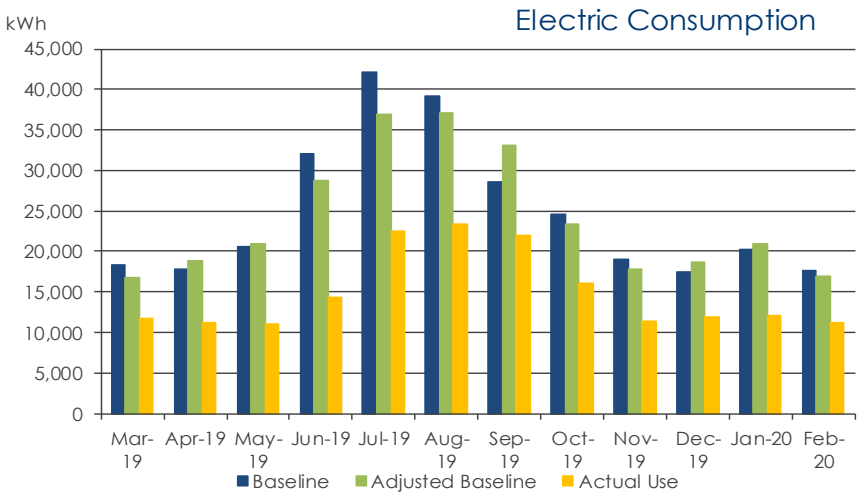


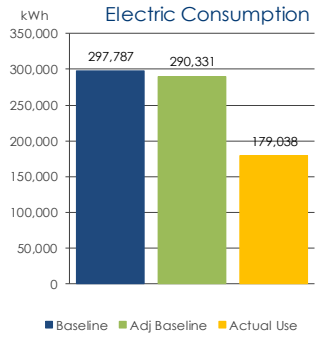
Facility Improvements:
* New supplemental electric heating in entries,
* Updated control sequences,
* New windows

East Lawrence Rec Center Electrical Performance

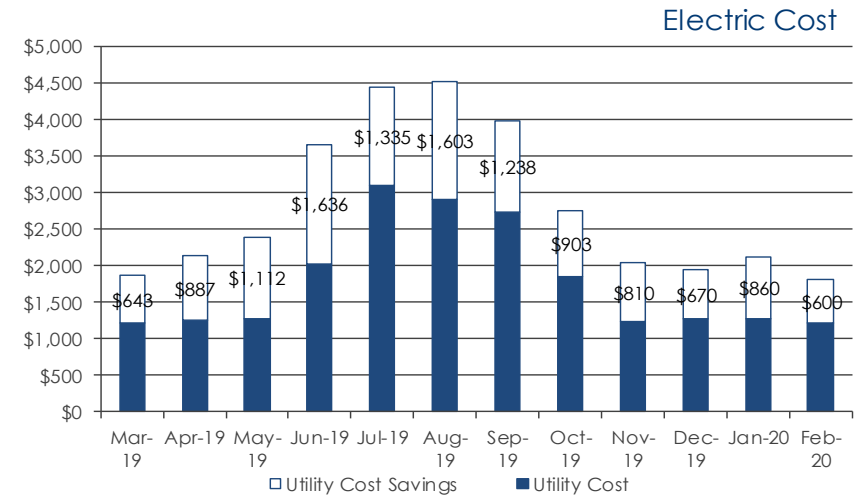
The following graphs illustrate the electrical performance for the East Lawrence Rec Center during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

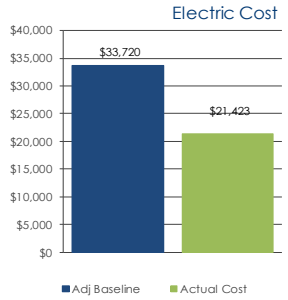






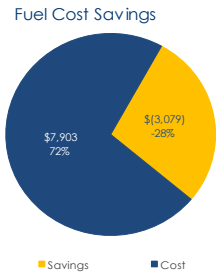
The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



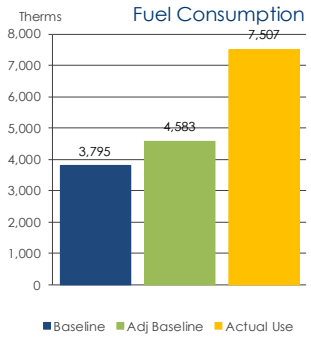


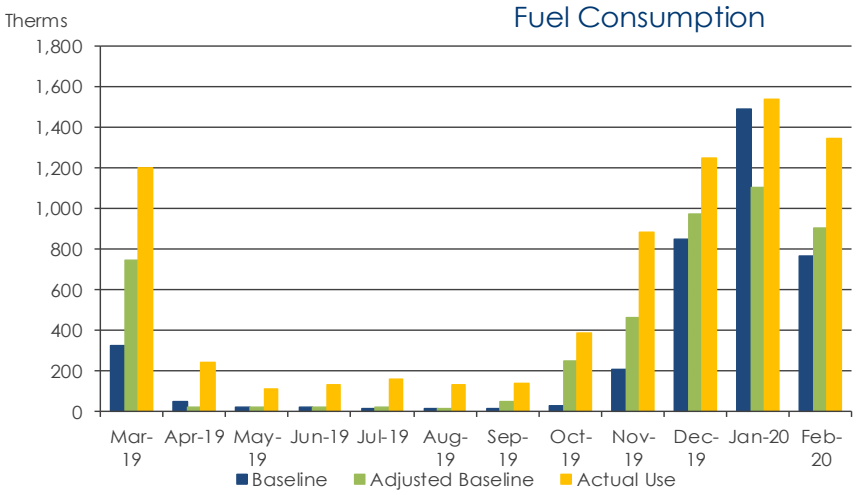
Facility Improvements:
* New packaged heating & cooling rooftop units (except W. side)
* Updated control sequences,
* LED lighting

East Lawrence Rec Center Fuel Performance

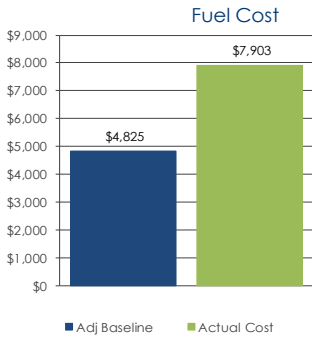


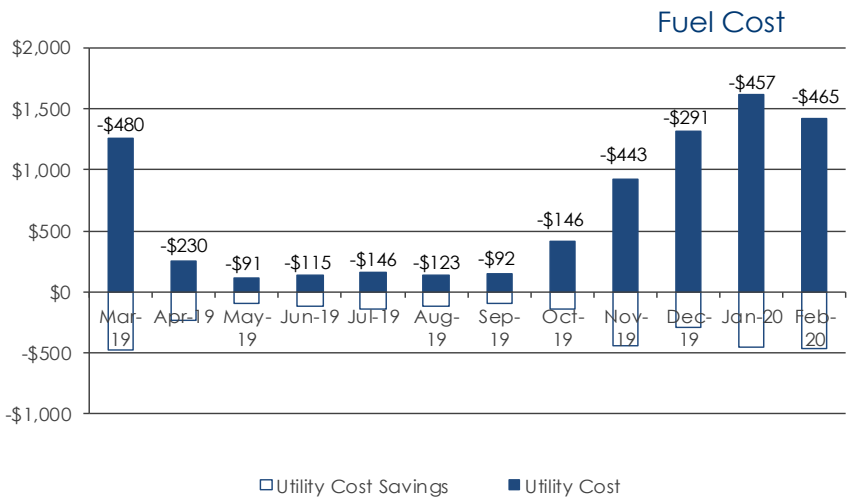
The following graphs illustrate the fuel performance for the East Lawrence Rec Center during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

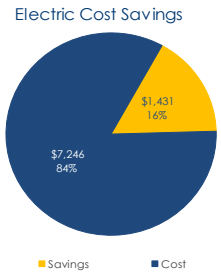


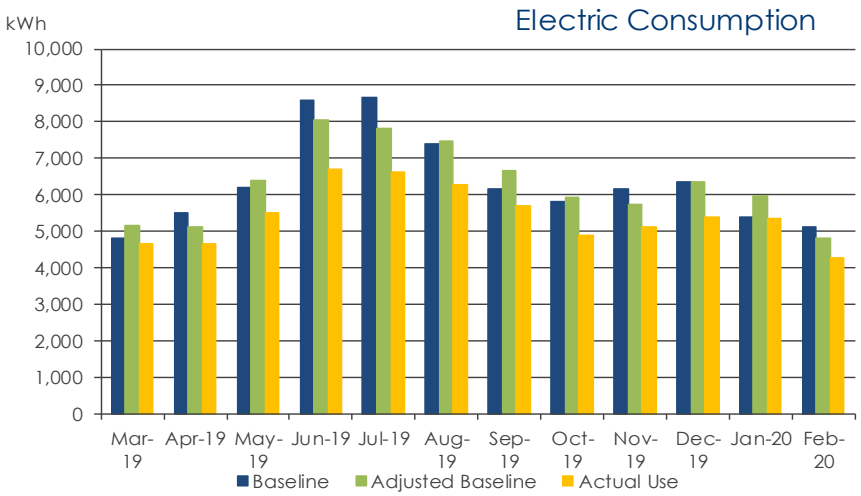


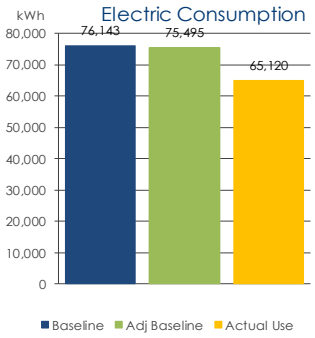
Facility Improvements:
* New packaged heating & cooling rooftop units (except W. side)
* Updated control sequences

Prairie Park Nature Center Electrical Performance

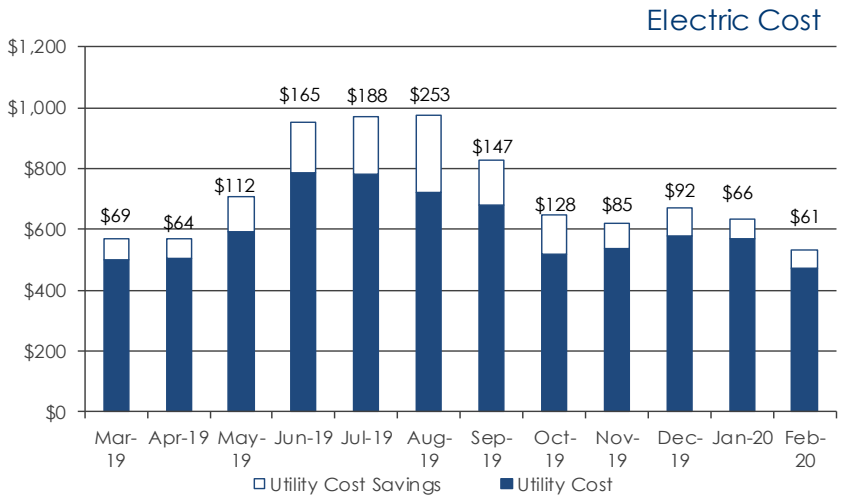
The following graphs illustrate the electrical performance for the Prairie Park Nature Center during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

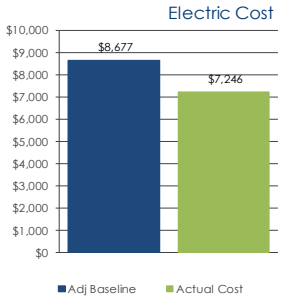






The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

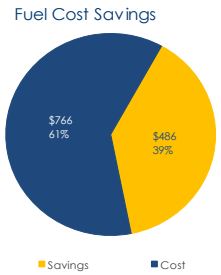




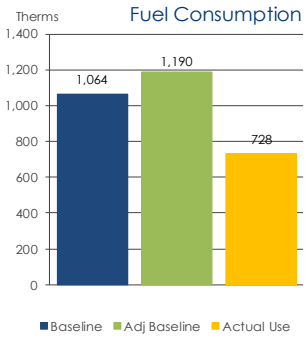
Facility Improvements:
* New AC split systems,
* New ventilation system,
* New DDC control system with updated sequences,
* LED lighting

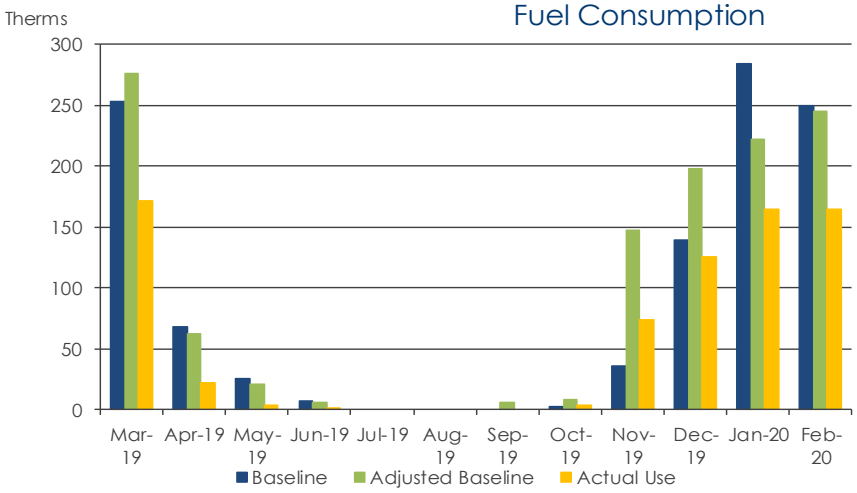
Bonus Improvements:
* New bipolar ionization cleaner on 3 split systems.

Prairie Park Nature Center Fuel Performance

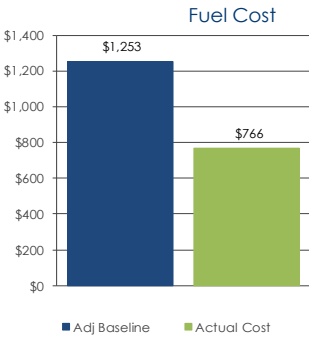


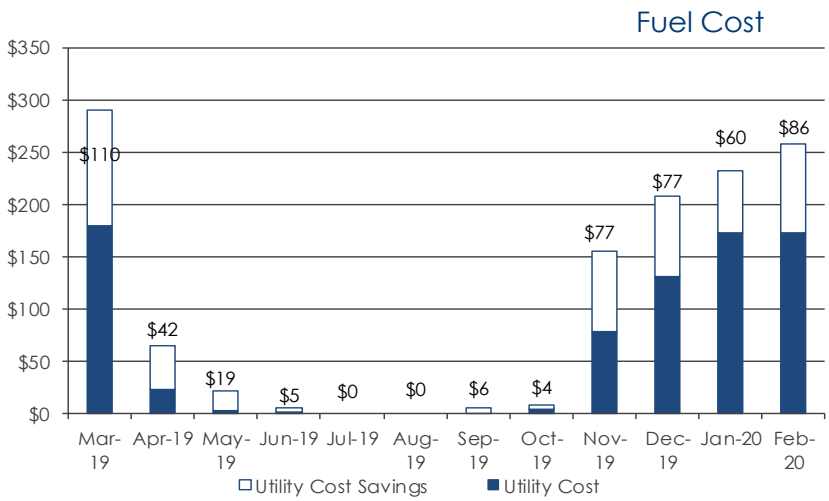
The following graphs illustrate the fuel performance for the Prairie Park Nature Center during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



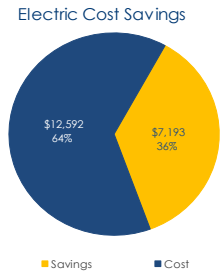


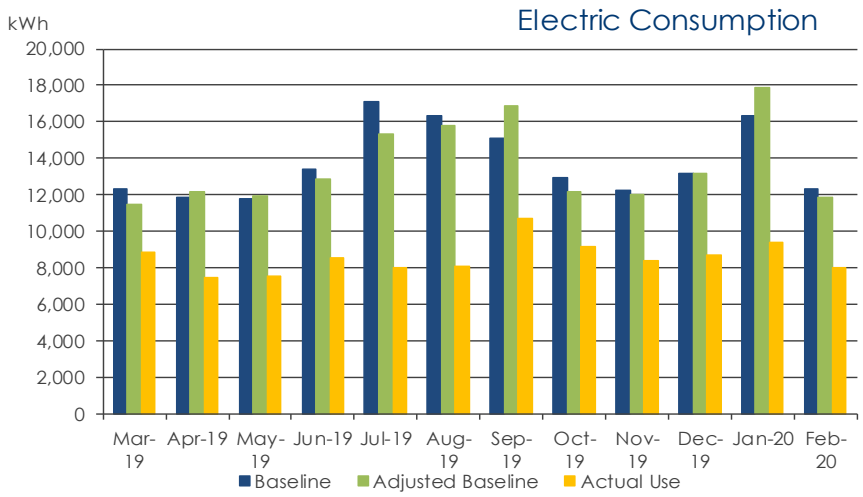
Facility Improvements:
* New gas furnaces,
* New ventilation system,
* New DDC control system with updated sequences

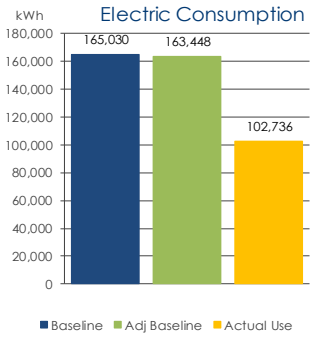
Bonus Improvements:
* New bipolar ionization cleaner on 3 furnaces.

Vehicle Maintenance Garage Electrical Performance

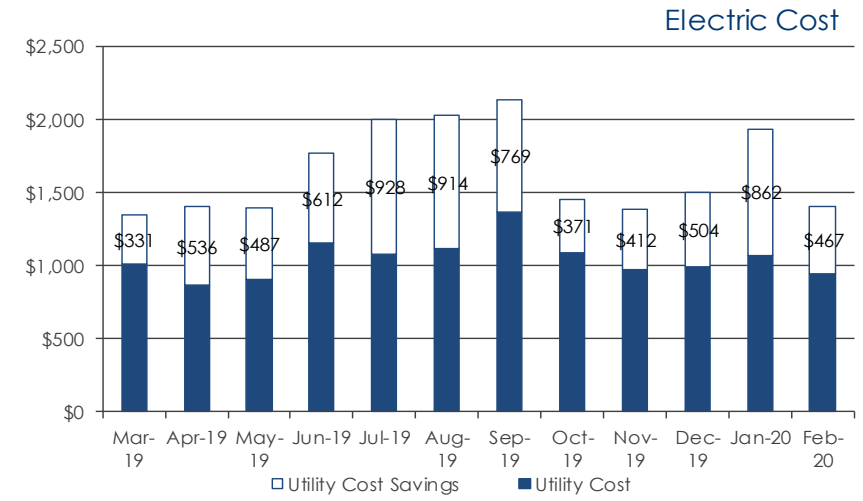
The following graphs illustrate the electrical performance for the Vehicle Maintenance Garage during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

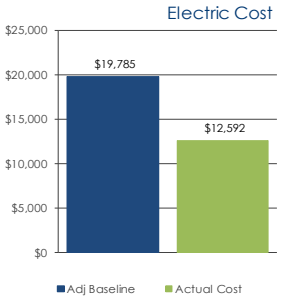






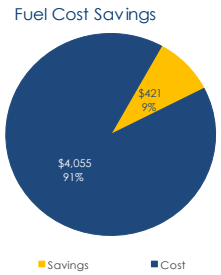
The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



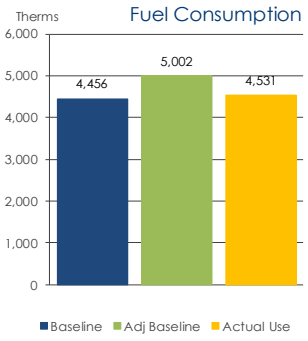


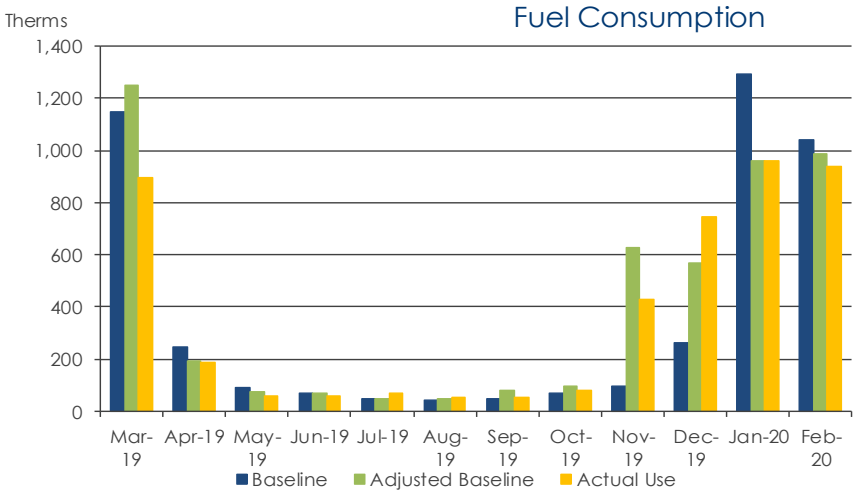
Facility Improvements:
* New AC ductless mini-split for Server Room,
* Internet-based thermostats,
* LED lighting

Vehicle Maintenance Garage Fuel Performance

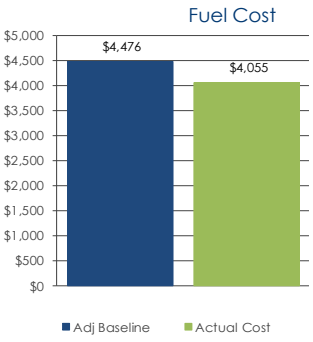


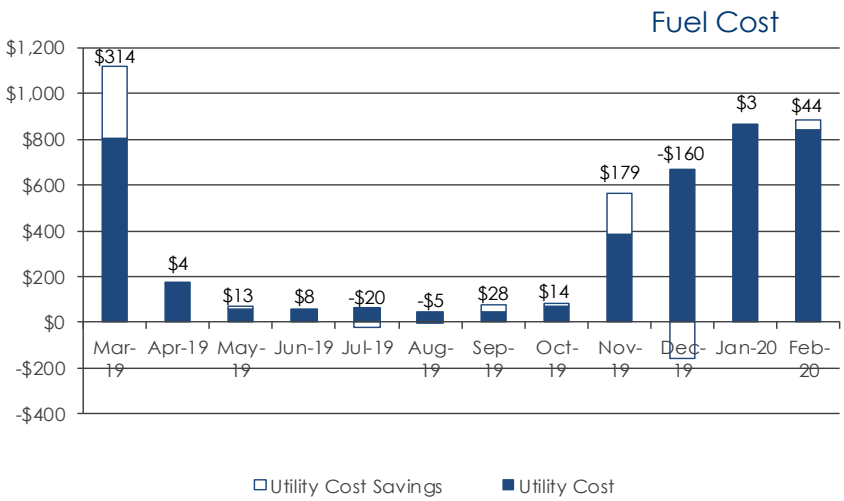
The following graphs illustrate the fuel performance for the Vehicle Maintenance Garage during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

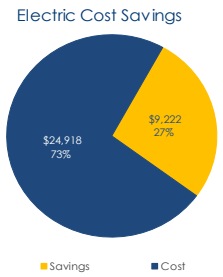


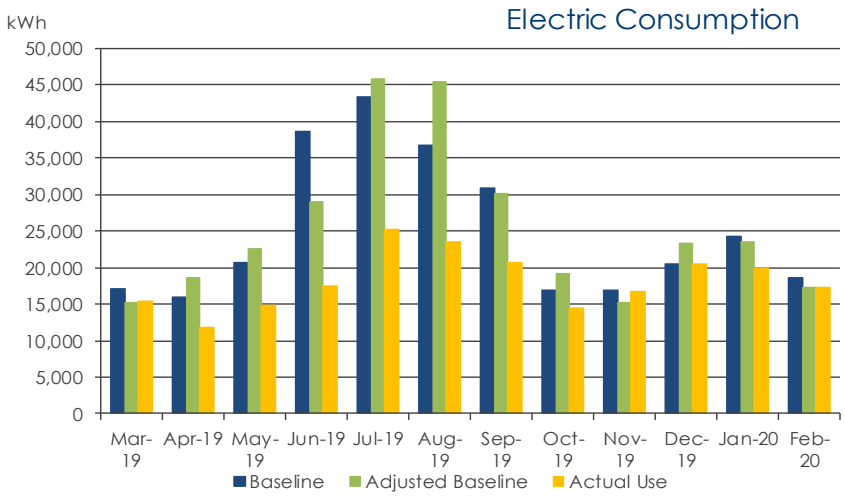


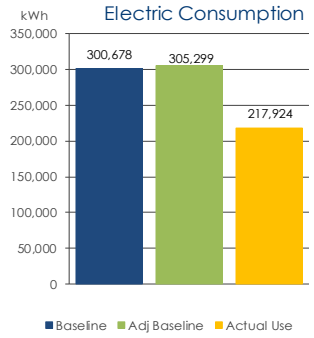
Facility Improvements:
* Internet-based thermostats

Community Building Electrical Performance

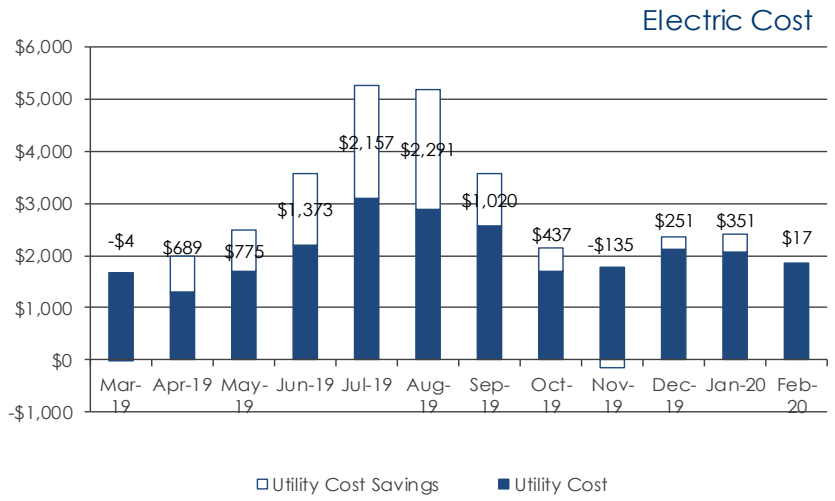
The following graphs illustrate the electrical performance for the Community Building during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.

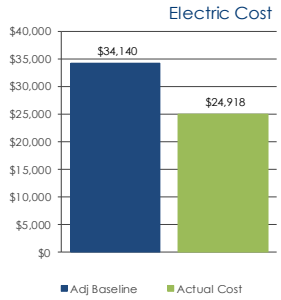






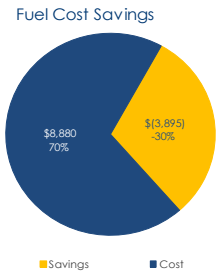
The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.



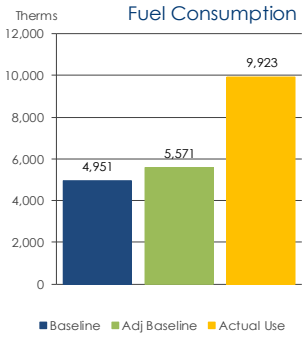


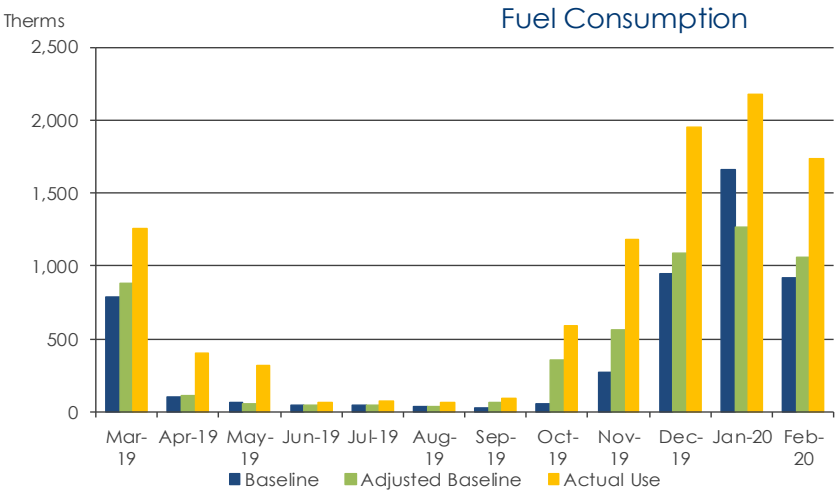
Facility Improvements:
* New packaged heating & cooling rooftop units (except RTU-11),
* Updated control sequences,
* New roof
* LED lighting

Community Building Fuel Performance

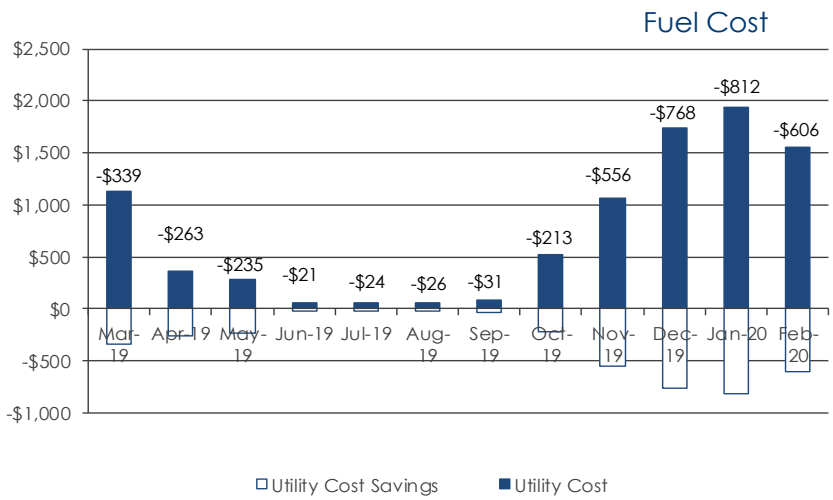


The following graphs illustrate the fuel performance for the Community Building during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





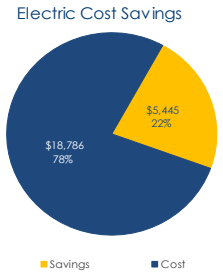
The graph below illustrates the monthly cost savings achieved through the project. The white bar represents savings, and the blue bar represents the new monthly costs.

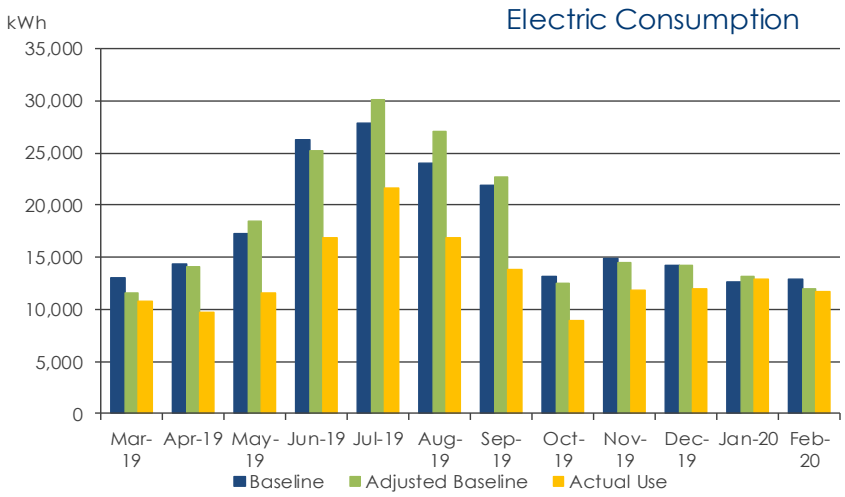


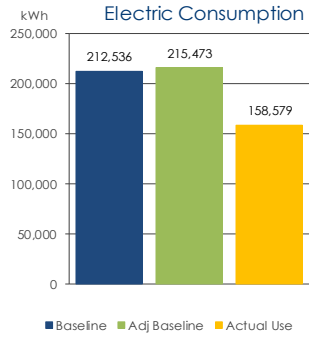
Facility Improvements:
* New packaged heating & cooling rooftop units (except RTU-11),
* Updated control sequences
* New roof

Holcom Park Rec Center Electrical Performance

The following graphs illustrate the electrical performance for the Holcom Park Rec Center during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in electrical usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated electric savings.







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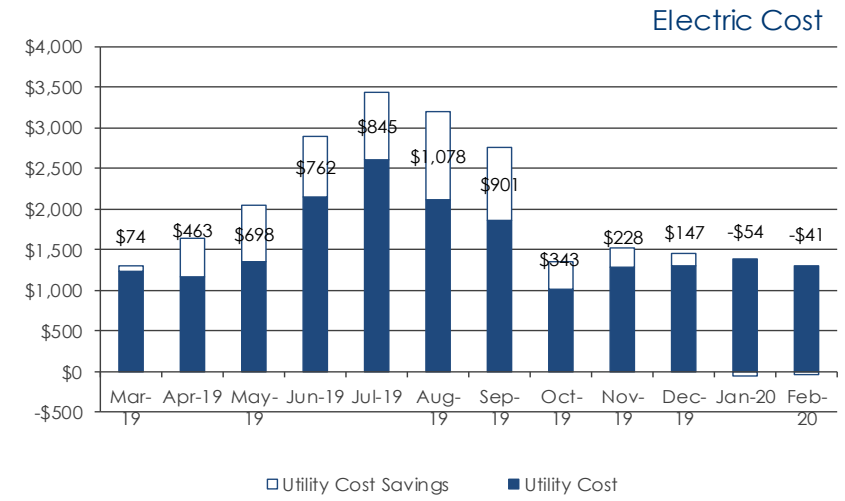
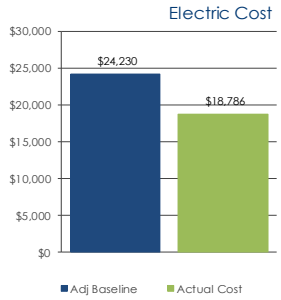
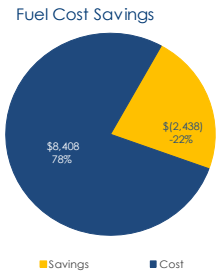




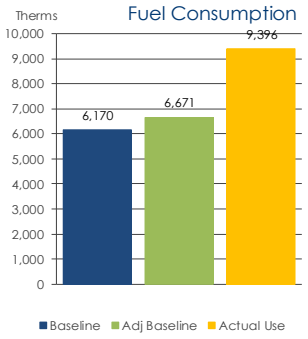
Facility Improvements:
* New packaged heating & cooling rooftop units for Gym,
* New gas duct heaters for air handlers (remove hydronic heating),
* Updated control sequences,
* LED lighting

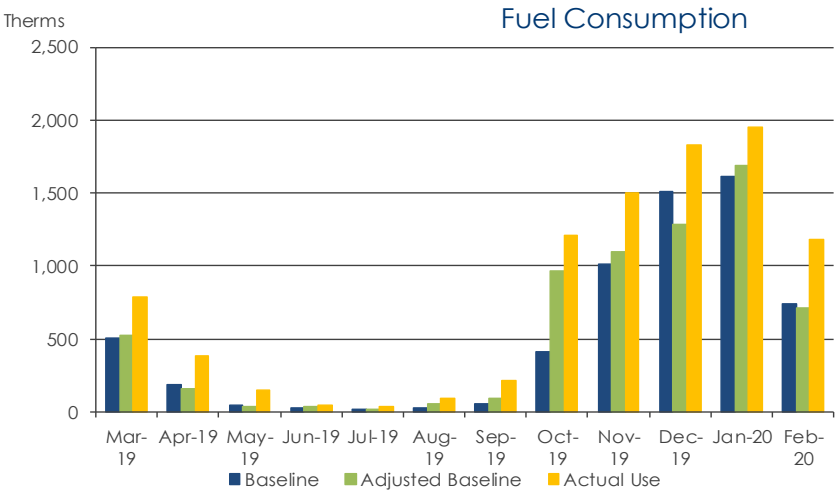
Bonus Improvements:
* Rebalance airflows to improve comfort

Holcom Park Rec Center Fuel Performance



The following graphs illustrate the fuel performance for the Holcom Park Rec Center during the measurement and verification period. The first graph below illustrates the weather adjustments and savings that occurred in fuel usage. The blue bar represents the baseline, the green bar represents the adjustments made to the baseline based on actual weather, and the yellow bar is the current usage. The difference between the blue and green bars is the savings (or loss) due to weather effects, and the difference between the green and yellow bars is the calculated fuel savings.





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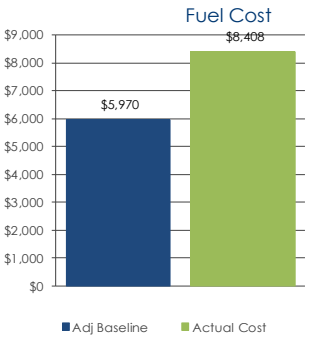
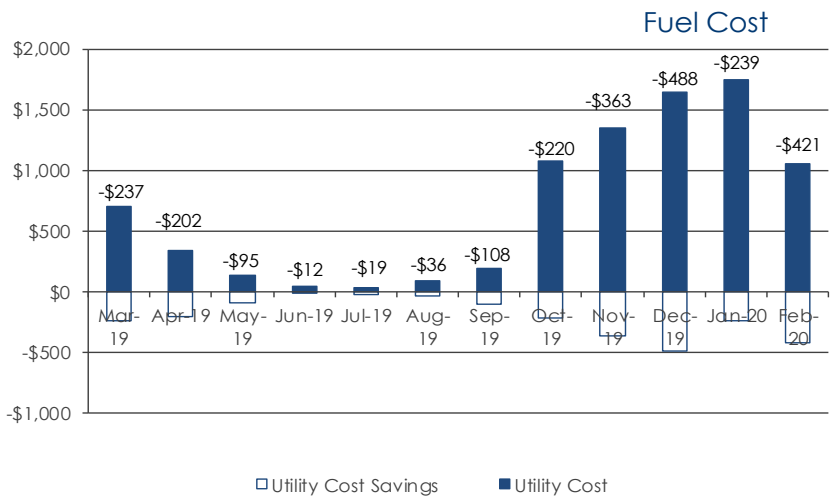




Facility Improvements:
* New packaged heating & cooling rooftop units for Gym,
* New gas duct heaters for air handlers (remove hydronics),
* Updated control sequences

Bonus Improvements:
* Retro-commission to improve comfort

Appendix

Overall Project Performance Summary

Since the start of the M&V process in March 2019, the City of Lawrence energy conservation project has resulted in total savings of over $1 million. This total savings includes $551,864 in year one and $543,507 in year two. In year one, the savings exceeded the Savings Guarantee by $3,845. In year two, the savings were just short of that guarantee by $2,190. Because of this savings shortfall in year 2, Willdan will reconcile the savings shortfall with a direct payment to the City of Lawrence in the amount of $2,190.

In the year one M&V report, it was noted that some buildings performed much better than others. In particular, the Indoor Aquatic Center performed well below expectations. In year two, the Indoor Aquatic Center continued to perform poorly compared to expectations. Willdan is preparing to improve that performance by coordinating with City staff to make system improvements at no additional cost.

Although the project did not meet the energy-saving guarantee in year two, the overall success of the project continues to provide numerous benefits to the City staff and visitors in each facility. Besides the quantifiable energy savings, the project scope has improved occupant comfort, improved indoor air quality, and reduced maintenance issues. Additionally, the reduced energy usage has positive effects on the City's carbon footprint and Greenhouse Gas emissions.

Indoor Aquatic Center – Building Performance

The Indoor Aquatic Center has not performed as well as expected during the Measurement and Verification period. As shown in previous sections of this report, both gas and electric savings are lower than predicted. Several issues contributed to this outcome, including project components that were not fully executed. A brief description of each issue and its impact is shown below.

Unoccupied Pool Turndown – Not Executed, Planned for Summer 2020

This measure has had the most impact on the expected savings. During construction, Willdan installed variable-speed drives for the pool circulation pumps. The intent was to reduce the amount of water pumped at night when the pools are closed. Building codes require a minimum amount of pumped water to travel through the filtration system. These same codes allow for a reduction in pumped water when the pool is unoccupied. The planned pumping reduction saves both electricity and heat.

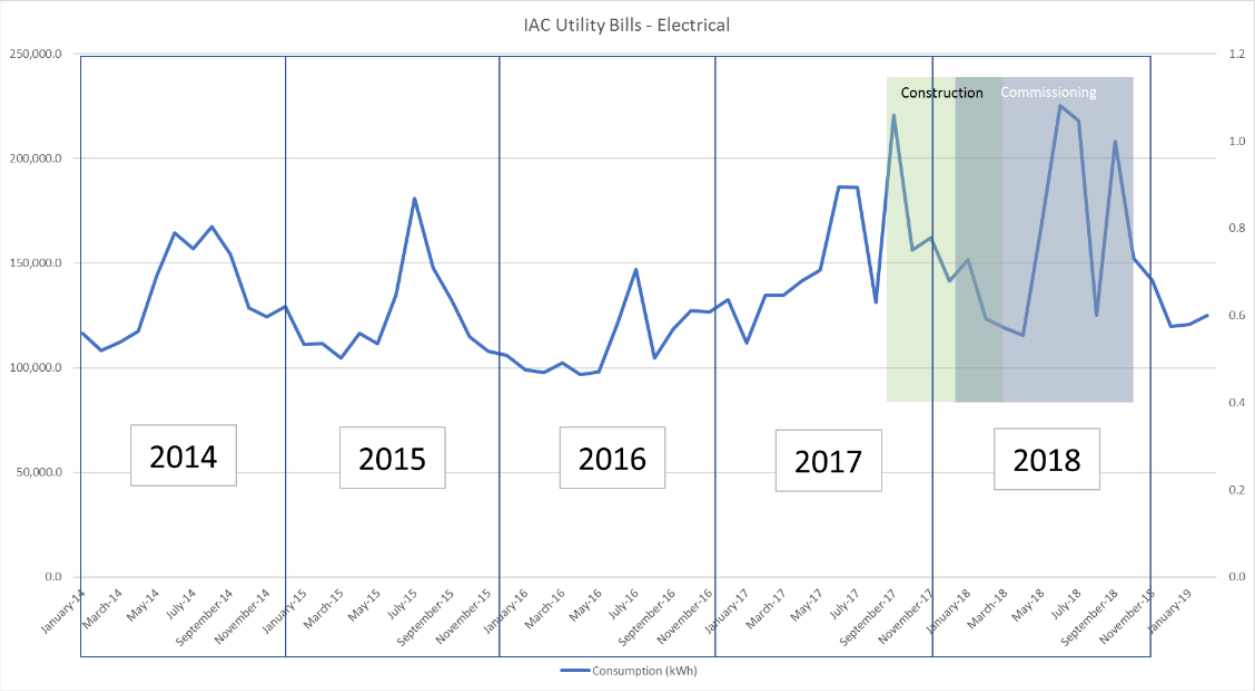
The pool pumps are in an underground vault below the mechanical room. The chemical treatment system is on the first level, in the mechanical room. To activate the chemical system, a portion of the circulated pool water is diverted to the chemical treatment system. Because the diverted water must move upward to reach the chemical treatment system, extra pressure, known as "head", is required. The existing piping system uses a manual reducing valve to provide necessary head in the diversion loop. When the pool water circulation pumps are slowed down, a manual adjustment of the reducing valve would be required to maintain enough head for the chemical treatment loop.

The manual reducing valve for artificial flow resistance is contrary to recommended design. A better design would be diverting the water at a point in the system where there is enough pressure for the chemical treatment system. An alternate approach would be the addition of an injection pump on the lower level that maintains required head without introducing artificial restrictions. Willdan is pursuing

modifying the piping on the first level at a point where adequate pressure will be provided for the chemical treatment system, and the large pool circulation pumps can be turned down at night to achieve the expected energy savings. This piping work along with the associated control sequence modifications required to implement pump turn-down during unoccupied times is planned for completion during the Summer 2020 pool shut down.

Leisure Pool Dehumidification Unit (DHU) - Consumes More than Expected

The Leisure Pool DHU was replaced as a separate project just prior to the Willdan construction project. The new DHU uses considerably more gas and electricity than the original unit that it replaced. The increase in electrical consumption can be seen in the summer months of 2017 in the graph below. This increase was not considered in the baseline calculations (2014-2015) used to determine cost savings. The extra utility costs incurred from the new Leisure Pool DHU continue to contribute to the overall utility costs of the Indoor Aquatic Center.



Pool Flow Meters – Not Accurate During IGA

During the Preliminary Analysis, Willdan engineers examined the existing flow meters for the pool circulation loops. They discovered that the pool circulation flows were higher than the design flow, resulting in wasted electrical energy. During the construction phase of the project, Willdan discovered that the circulation flow meters gave inaccurate readings. The actual pool circulation flows were *at or lower* than design flows. The circulation flow had to be increased rather than lowered in order to meet design flows, which not only eliminated the potential savings but also created negative savings.

Summary

The unexpected variations to the Willdan design and energy calculations have changed the expected utility costs of the Indoor Aquatic Center. Willdan continues to monitor the IAC building performance and can make further recommendations for energy reduction if the City of Lawrence would like to explore potential opportunities. While net project savings city-wide offset the poorer than expected

performance at the IAC, Willdan recognizes individual building performance still creates challenges, and we are committed to helping the City with continued documentation of building performance and savings to assist in utility budget allocations, etc.

Utility Rate Adjustment

The utility rates were adjusted for the current year's CPI according to Schedule C, Section 7 of the contract.

Table 1 - Utility Rates used for determining Actual Energy Savings

Utility Rate	Program Year	Electric Rate
Westar MGS	0	$ 0.0470 / kWh (Jun – Sept) $ 0.0390 / kWh (all other months) $ 22.22 / kW (all months)
Westar SGS	0	$ 0.0850 / kWh (all months) $ 8.47 / kW (Jun – Sept) $ 5.38 / kW (all other months)
Natural Gas (Low Rate)	0	$ 0.70 / Therm
Natural Gas (Medium Rate)	0	$ 0.85 / Therm
Natural Gas (High Rate)	0	$ 1.00 / Therm
All Rates	Future Years	Year zero rate adjusted for current year's CPI or future year's actual rate, whichever is greater.

The current year's CPI was determined using the CPI Table for the Mid-Atlantic region on the U.S. Bureau of Labor Statistics' website:

https://www.bls.gov/regions/mid-atlantic/data/consumerpriceindexhistorical_us_table.htm

The CPI for March 2017 was used for the Baseline (year zero) CPI since the Contract Start Date was 2/28/2017. The average CPI was used for the Year 2 Performance Period (future year) CPI of March 2019 to February 2020 as follows:

CPI for 3/2017 = 243.801
Avg. CPI for 3/2019 to 2/2020 = 256.6708

Rate adjustment = (256.6708 – 243.801) / 243.801 = 0.0528

New Rates:

Westar MGS	$0.0495 / kWh (June – Sept) $0.0411 / kWh (all other months) $23.93 / kW (all months)
Westar SGS	$0.0895 / kWh (all months) $8.917 / kW (June – Sept) $5.664 / kW (all other months)
Natural Gas (Low Rate)	$0.737 / Therm
Natural Gas (Medium Rate)	$0.895 / Therm
Natural Gas (High Rate)	$1.053 / Therm

Baseline Energy Adjustments – Included in Savings

The following condition was identified which according to the contract need to be analyzed to determine adjustments to the Baseline Consumption for Year 2.

City Hall 24/7 Operation

In December 2019, Willdan identified an issue at City Hall where the 2 main rooftop units (RTUs) were not disabling and the FPBs were not maintaining their Unoccupied Setpoints, but instead were controlling to their Occupied Standby Heating setpoint during Unoccupied times; which indicated the building was no longer controlling to the Occupancy Schedule. The FPBs would go into Standby mode because the occupancy sensors would not be triggered when the building was Unoccupied; however, the Standby Heating Setpoints had been adjusted to 70F throughout most of the building. Willdan notified Jason Stowe on 2/25/2020 & the Standby Heating Setpoint was adjusted according to the contract of (-5F) below Occupied Heating Setpoint. Robert Herring (JCI Tech.) emailed on 2/28/2020 that he identified the issue with the units staying occupied:

"I looked at this today and there is a fault in the RTU that is causing the fan to stay running. The fan status is showing "On-Gas Valve or Limit Fault". I spoke to one of our mechanics and he said that when it sees a trip it will keep the fan running as a safety. If you need I can have one our mechanics out next week to look into the issue."

Willdan confirmed with trends the issue appeared to be resolved on 3/1/2020. Therefore, an analysis was performed to calculate the additional energy usage for operating the 2 RTUs for 24/7 operation controlling to the Occupied Heating Setpoint of 70F for Dec. 2019 through Feb. 2020.

Dec. 2019: 20,341 kWh @ $0.0411 / kWh → **$835.16**

Jan. 2020: 19,472 kWh @ $0.0411 / kWh → **$810.56**

Feb. 2020: 16,478 kWh @ $0.0411 / kWh → **$676.55**

Total adjustment = $2,322.27

Note: The analysis showed there was no additional gas usage which makes sense given the FPBs have electric reheat & the gas heating on the RTUs is usually only utilized for morning recovery from setback.

Baseline Energy Adjustments – Not included in Savings

The following conditions were identified which according to the contract could be analyzed to determine adjustments to the Baseline Consumption. However, the adjustment associated with each item was not analyzed since Year 1 Savings produced enough savings to meet the guarantee. The items have been included in the Appendix for informational purposes to illustrate that additional savings beyond those reported could have been achieved.

City Setpoint Policy Changes updated January 1, 2018

Due to numerous comfort complaints at various buildings in both heating & cooling season, the city elected to update the setpoint policy on January 1, 2018 (Policy #121). Sections of the policy document have been included below:

All interior office workspaces within the City must have the following setpoints.
During normal operating hours, thermostats shall have a setpoint between 68°F and 72°F during the heating season and between 72°F and 76°F during the cooling season.
The following spaces are exempt from the aforementioned standards:

a) *Pool spaces shall be kept at 2°F above pool water temperature setpoints;*
b) *Gyms, community gathering areas, locker rooms and other changing areas shall be set for occupant comfort; and*
c) *Residential sleeping quarters for first responders may have a setpoint between 70°F and 76°F during the cooling season.*

The setpoints in red above conflict with the contractual setpoints in Schedule I, Section 1 of the contract (see below) and would result in increased energy consumption.

1) **HVAC systems: ESCO will install systems capable of maintaining the following standards of comfort:**
   a) **Occupied heating set points: 70°F**
   b) **Occupied cooling set points: 74°F**

Community Health Building Dirty Electrostatic filters

Dale notified Willdan in January 2020 that the filter media for the dynamic air cleaners installed on the air handlers were "pretty packed" and he would be ordering new filter media for replacement. Operating the air handlers with dirty filters increases the energy consumption as the supply fan requires more energy to overcome the higher pressure drop of the dirty filter. Since the time duration for operating with the dirty filters was unknown, an adjustment for this additional energy was not calculated.

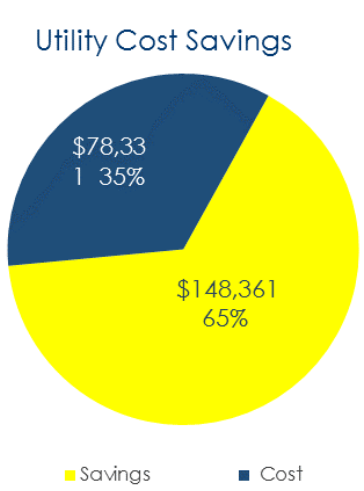
Option A Measurement & Verification of Electrical Energy Savings

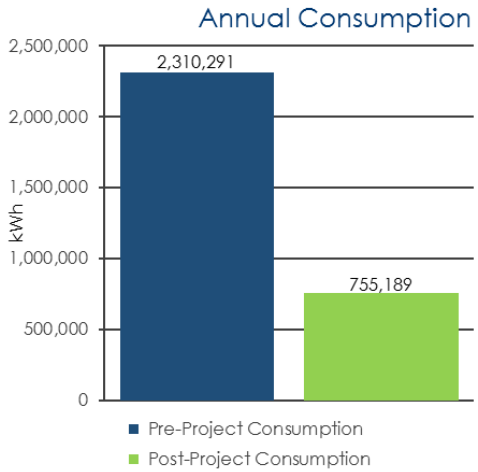
The table below demonstrates the amount of savings achieved throughout all facilities in which Option A Savings was calculated. The table breaks down the essential measured parameters (kWh, kW) which were used to determine the achieved savings. Based on the analysis performed, the facilities saw a combined savings of $**166,406** this was $27,651 more than the guaranteed savings of $**138,755**. The graphs shown below the table are to illustrate the impact the energy saving measures have had on your facilities.

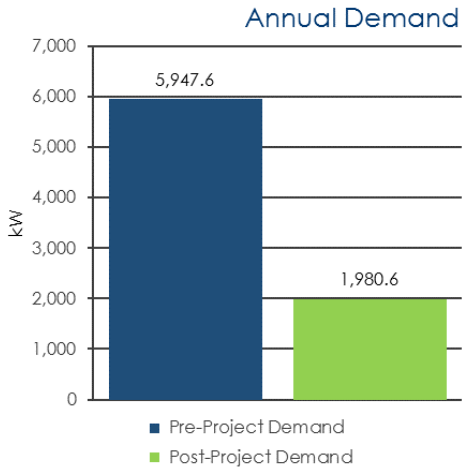
City-Wide Building Lighting

Building Name	Pre-Project Consumption (kWh)	Pre-Project Demand (kW)	Pre-Project Cost ($)	Post-Project Consumption (kWh)	Post-Project Demand (kW)	Post-Project Cost ($)	Consumption Savings (kWh)	Annual Demand Savings (kW)	Annual Savings ($)
Edgewood Park	24,847	68.1	$ 2,541	6,721	18.4	$ 789	18,126	49.7	**$ 1,752**
Hand Park	1,308	3.6	$ 266	301	0.8	$ 168	1,007	2.8	**$ 97**
Hobbs Park	8,681	36.1	$ 1,020	1,735	4.8	$ 307	6,946	31.3	**$ 713**
Holcomb Park	2,854	7.8	$ 415	587	1.6	$ 196	2,267	6.2	**$ 219**
Japanese Garden	1,586	4.3	$ 293	293	0.8	$ 168	1,293	3.5	**$ 125**
John Taylor Park	9,442	25.9	$ 1,052	2,307	6.3	$ 362	7,136	19.5	**$ 690**
Ludlam Park	2,178	6.0	$ 350	1,079	3.0	$ 244	1,099	3.0	**$ 106**
Lyons Park	6,672	18.3	$ 784	95	1.8	$ 154	6,577	16.5	**$ 630**
Prairie Park	6,174	16.9	$ 736	1,395	3.8	$ 274	4,778	13.1	**$ 462**
Rotary Arboretum	837	2.3	$ 220	117	0.3	$ 151	721	2.0	**$ 70**
South Park	35,107	96.2	$ 3,533	8,056	22.1	$ 918	27,051	74.1	**$ 2,615**
Walnut Park	2,615	7.2	$ 392	602	1.6	$ 198	2,014	5.5	**$ 195**
Youth Sports Complex	56,419	154.6	$ 5,593	15,728	43.1	$ 1,660	40,691	111.5	**$ 3,933**
Carnegie Buildings	16,291	77.9	$ 1,648	6,083	41.3	$ 744	10,208	36.6	**$ 905**
27th Street Maintenance E	11,905	45.6	$ 1,199	6,270	24.0	$ 698	5,634	21.6	**$ 502**
Eagle Bend Clubhouse and	9,543	25.4	$ 977	4,285	11.6	$ 518	5,258	13.7	**$ 458**
New Hampshire Parking Ga	349,215	530.4	$ 32,458	73,231	117.6	$ 6,938	275,984	412.8	**$ 25,520**
Union Pacific Depot	23,184	76.9	$ 2,284	6,593	26.3	$ 748	16,591	50.6	**$ 1,536**
Solid Waste	8,390	34.7	$ 855	4,512	18.5	$ 523	3,878	16.3	**$ 331**
South Park Admin	13,635	58.9	$ 1,316	5,360	33.3	$ 635	8,275	25.6	**$ 681**
Outdoor Aquatic Center	7,924	167.0	$ 1,394	3,135	58.4	$ 610	4,789	108.6	**$ 784**
Street Division Office + Re	27,164	122.8	$ 2,928	11,329	54.7	$ 1,314	15,835	68.1	**$ 1,614**
Riverfront Garage and Sur	103,482	196.3	$ 9,848	29,441	49.3	$ 2,879	74,041	147.0	**$ 6,969**
Salt Domes and Wakarusa	20,863	79.0	$ 2,229	5,160	17.4	$ 649	15,702	61.6	**$ 1,580**
North Lawrence Pump Sta	13,012	38.7	$ 1,407	3,523	11.3	$ 485	9,488	27.4	**$ 922**
Parks and Rec Maintenanc	13,103	50.2	$ 1,454	7,064	27.1	$ 848	6,039	23.1	**$ 606**
Downtown Parking Lots an	9,887	27.1	$ 1,095	2,924	8.0	$ 422	6,964	19.1	**$ 673**
Broken Arrow Park	8,325	22.8	$ 944	2,173	6.0	$ 349	6,152	16.9	**$ 595**
Brook Creek Park	4,186	11.5	$ 544	342	0.9	$ 172	3,844	10.5	**$ 372**
Burcham Park	864	2.4	$ 223	13	0.0	$ 141	851	2.3	**$ 82**

Building Name	Pre-Project Consumption (kWh)	Pre-Project Demand (kW)	Pre-Project Cost ($)	Post-Project Consumption (kWh)	Post-Project Demand (kW)	Post-Project Cost ($)	Consumption Savings (kWh)	Annual Demand Savings (kW)	Annual Savings ($)
Centennial Park	27,464	75.2	$ 2,794	6,684	18.3	$ 785	20,780	56.9	**$ 2,008**
Chief Jim McSwain Park	6,095	16.7	$ 728	1,551	4.3	$ 289	4,544	12.4	**$ 439**
Clinton Park	10,367	28.4	$ 1,141	2,115	5.8	$ 344	8,252	22.6	**$ 798**
Constant Park	4,656	12.8	$ 589	1,208	3.3	$ 256	3,448	9.4	**$ 333**
Dad Perry Park	11,904	32.6	$ 1,290	406	1.1	$ 179	11,498	31.5	**$ 1,111**
Deerfield Park	11,299	31.0	$ 1,231	2,691	7.4	$ 399	8,608	23.6	**$ 832**
Eagle Bend Golf	4,186	11.5	$ 544	558	1.5	$ 193	3,628	9.9	**$ 351**
Maintenance Building	41,709	154.4	$ 3,734	8,039	31.2	$ 837	33,670	123.1	**$ 2,897**
Community Hangar	44,731	122.6	$ 4,463	4,854	13.3	$ 609	39,876	109.3	**$ 3,854**
Hangar A	8,393	41.9	$ 1,014	1,585	5.8	$ 298	6,809	36.0	**$ 717**
Hangar B	7,353	74.2	$ 1,032	1,630	10.9	$ 318	5,723	63.3	**$ 714**
Hangar C	7,208	70.7	$ 1,008	1,552	9.0	$ 305	5,657	61.7	**$ 702**
Sports Pavilion	945,164	2,219.6	$ 90,250	378,107	887.9	$ 36,187	567,057	1,331.6	**$ 54,062**
Lawrence Street Lighting	380,067	1,041.3	$ 36,875	133,755	366.5	$ 13,067	246,313	674.8	**$ 23,807**
Totals	2,310,291	5,947.6	$ 226,692	755,189	1,980.6	$ 78,331	1,555,102	3,967.1	**$ 148,361**

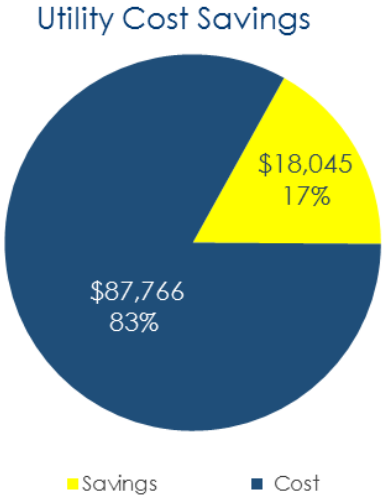


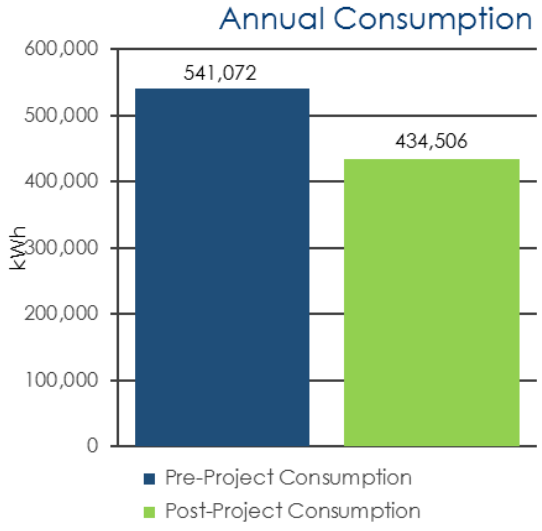


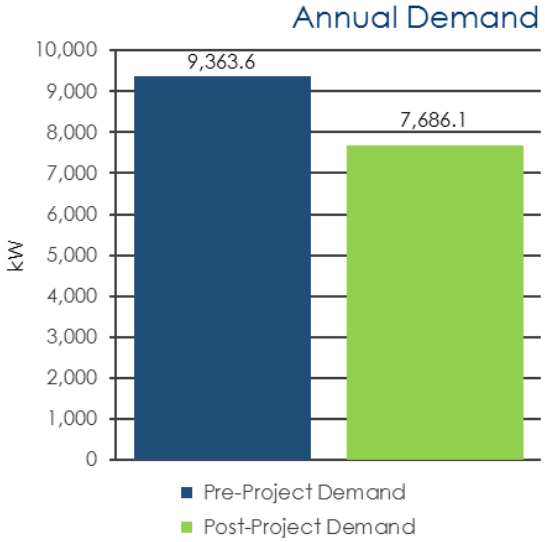


Sports Field Lighting

Building Name	Pre-Project Consumption (kWh)	Pre-Project Demand (kW)	Pre-Project Cost ($)	Post-Project Consumption (kWh)	Post-Project Demand (kW)	Post-Project Cost ($)	Annual Consumption Savings (kWh)	Annual Demand Savings (kW)	Annual Savings ($)
Broken Arrow Park	28,965	554.3	$ 4,537	17,233	329.8	$ 2,756	11,732	224.5	**$ 1,781**
Centennial Park	7,167	137.2	$ 1,228	4,420	84.6	$ 811	2,747	52.6	**$ 417**
Chief Jim McSwain Park	2,867	54.9	$ 575	1,768	33.8	$ 408	1,099	21.0	**$ 167**
Deerfield Park	4,300	82.3	$ 792	2,652	50.8	$ 542	1,648	31.5	**$ 250**
Holcomb Park	11,468	219.5	$ 1,881	7,073	135.4	$ 1,213	4,395	84.1	**$ 667**
Lyons Park	57,552	1,101.5	$ 8,878	46,656	892.9	$ 7,224	10,896	208.5	**$ 1,655**
Veterans Park	8,601	164.6	$ 1,445	5,304	101.5	$ 945	3,296	63.1	**$ 501**
Youth Sports Complex	383,249	6,851.0	$ 81,812	325,570	5,945.7	$ 70,718	57,679	905.3	**$ 11,094**
Holcom	-	-	$ 139	3,484	9.5	$ 476	(3,484)	(9.5)	**$ (337)**
Clinton Softball Complex	2,405	6.6	$ 305	5,229	14.3	$ 500	(2,824)	(7.7)	**$ (195)**
19th and Moodie	14,374	80.0	$ 1,665	5,932	41.0	$ 796	8,442	39.0	**$ 869**
Horticulture	9,836	46.7	$ 1,157	5,192	24.8	$ 677	4,644	21.9	**$ 480**
Oak Hill Cemetery	3,718	27.0	$ 555	935	5.6	$ 240	2,783	21.4	**$ 315**
15th Street Cemetery	6,572	38.0	$ 842	3,059	16.3	$ 462	3,513	21.7	**$ 380**
Totals	541,072	9,363.6	$ 105,812	434,506	7,686.1	$ 87,766	106,566	1,677.5	**$ 18,045**







Option A Measurement & Calculated Savings Methodology

The following section explains how measurements were taken to determine the savings achieved.

A. Savings calculated for Option A were determined by following the guidelines laid out in the International Performance Measurement & Verification Protocol Volume I. As prescribed by the instructions for Option A: Partially Measured Retrofit Isolation, the equipment affected by the energy conservation measures (ECM) was isolated and measured prior to the retrofit, and again post retrofit, to determine the impact of the ECM on the energy usage of the equipment.

B. Sampling was conducted to obtain a 90% confidence and 20% precision according to Appendix B of the *Federal Energy Management Program (FEMP) M&V Guidelines v4.0*. The purpose of sampling is to monitor a representative sample of points rather than the entire population. The end result is to obtain reliable estimates within a specified precision and statistical confidence. The basic equation used in sample group sizing for 90% confidence and 20% precision is:

$$n = \frac{z^2 \cdot (C_v)^2}{(P)^2} = \frac{(1.645)^2 \cdot (0.5)^2}{(0.2)^2} = 16.91$$

Where, z = Z-statistic, 1.645 for 90% confidence; C_v = Coefficient of Variance, 0.5; P = Precision, 20%.

For populations less than 500, the sample size should be modified using the finite population correction equation:

$$n^* = \frac{Nn}{n+N}$$

Where, n* = sample size corrected for population size; n = sample size for infinite population; N = population size.

Furthermore, the sample size includes a 10% oversampling factor in case of data collection device failure or unexpectedly high data scatter.

$$n^* = \frac{Nn}{n+N} = \frac{(92)(16.91)}{16.91+92} = 14.28\ x\ 10\% = 15.7 = 16$$

C. Pre-retrofit & post-retrofit measurements were taken at the various fixtures themselves, and then the average difference between the measurements was applied to all the fixtures in the sample set. The resulting savings was evaluated using the average occupancy, operations, and annual use to determine the total building energy savings.

D. Pre-retrofit & post-retrofit annual usage was estimated for each fixture to calculate an annual consumption for each building.

E. Pre-retrofit & post-retrofit annual consumption was then multiplied by the contractual energy rates to determine the annual energy costs.

F. The pre-retrofit energy cost was then compared to the post-retrofit energy cost to determine the annual energy savings solely from the energy conservation measure.

Solar PV Performance and Savings

The 100kW Solar PV array was installed on the roof of Fire/Medical #5 (1911 Stewart Ave.) in the summer of 2017. Since that time, this system has produced 626,000 kWh (245,000 kWh in Year 1 & 381,000 kWh in Year 2) of electrical power that would have been purchased from the electric utility.

Equivalent savings to 626,000 kWh includes the following:

CO_2 emissions from

49,804	-or-	487,692	-or-	74.9
gallons of gasoline consumed		Pounds of coal burned		homes' electricity use for one year

Greenhouse gas emissions from

95.6	-or-	1,098,280
Passenger vehicles driven for one year		Miles driven by an average passenger vehicle

Carbon sequestered by

7,319	-or-	578
tree seedlings grown for 10 years		acres of U.S. forests in one year

Source: www.epa.gov/energy/greenhouse-gas-equivalencies-calculator