Bright Lights and Charged Cars

A Feasibility Study of Energy Efficiency Improvements for Saratoga Springs

Martha Belshaw, Michaela Bonforte, and Nicholas DeBlasio

Skidmore College Senior Capstone Project in Environmental Studies
Dr. Karen Kellogg, Project Advisor
May 6, 2019

Acknowledgements
We would like to thank the following individuals and businesses for their support and assistance throughout the year. This project could not have been completed without them.

Karen Kellogg, PhD, Skidmore College, Director and Associate Professor of Environmental Studies and Sciences Program

Andrew J. Schneller, PhD, Skidmore College, Visiting Assistant Professor of Environmental Studies and Sciences Program

Tina Carton, City of Saratoga Springs, Director of Parks, Open Space, Historic Preservation, and Sustainability

Dan Rancour, City of Saratoga Springs, Senior Electrician

Mike Sharp, City of Saratoga Springs, Deputy Commissioner of Finance

Lt. Aaron Dyer, Saratoga Springs Fire Department, Fire Prevention Lieutenant

Chief Pete Shaw, Saratoga Springs Fire Department, Assistant Fire Chief

Karl Pedersen, Wolberg Electric Supply

Christopher Morris, W.W. Grainger, Inc.

Levi Rogers, Skidmore College, Director of Sustainability Programs and Assessments

Paul Lundberg, Skidmore College, Assistant Director of Construction Services

ChargePoint, Inc.

Sternberg Lighting

Abstract

Saratoga Springs has been a Climate Smart Community engaged in reducing their greenhouse gas emissions and improving climate resilience since 2011, but there is room for improvement in the city's energy efficiency sector. Similarly to most cities, Saratoga Springs consumes large amounts of electricity, a majority of which is dedicated to public lighting. From historic street lighting and city building indoor lighting alone, Saratoga Springs consumes approximately 6.7 million kWh annually. One way to decrease this energy demand is by replacing the current fixtures with energy efficient LED lighting technology. Financial and environmental analyses showed a positive impact on the historic street lighting and indoor lighting of Saratoga Springs. Overall, the city will experience total energy savings of 328,845 kWh per year, electricity cost savings of $151,519 in ten years, and annual greenhouse gas emissions savings of 61.6 MT eCO_2. In order to increase these savings more, multiple electric vehicle charging stations should be installed throughout Saratoga Springs. The number of electric vehicle registrations in Saratoga Springs nearly doubled from 2017 to 2018 and the city should provide the community with the appropriate amount of charging stations. Three stations will decrease the city's greenhouse gas emissions by 45 MT eCO_2, which increases the total emissions savings of the city to more than 100 MT eCO_2. After the initial investment of purchasing and installing the stations has been returned, the city will experience total savings of approximately $1,000 annually. In ten years, the savings from the electric vehicle charging stations will increase the total financial savings for the city to $153,826. The implementation of LED lighting in both the city building indoor lights and historic street lights, as well as the installation of new EV charging stations, will increase the energy efficiency and decrease the greenhouse gas emissions of Saratoga Springs, while also expanding the sustainability portfolio of the city.

Table of Contents

Introduction

Saratoga Springs is a historically significant city in upstate New York that was founded in 1776. As of 2016, the population of the city was approximately 27,700 residents. Saratoga Springs is well known for its mineral springs and thoroughbred racing, but it is also a city that is committed to sustainable initiatives. In fact, Saratoga has been a Climate Smart Community since 2011. Climate Smart Communities are a network of New York cities and towns engaged in reducing greenhouse gas emissions and improving climate resilience. Ever since the city adopted the Climate Smart Community pledge, Saratoga Springs has successfully addressed all of their pledge elements with sustainable projects such as solar field installations, natural resource inventorying, and bicycle sharing (Birge, 2015). The city is interested in continuing their sustainable efforts by increasing their energy efficiency. This study proposes improvements to Saratoga Springs' historic street and indoor lighting as well as the expansion of the electric vehicle charging stations program in order to achieve the city's goal.

Lighting has one of the greatest electricity demands for municipalities across the country. The state of New York alone is illuminated by approximately 1.4 million municipal street lights. These lights require more than 990 Gigawatt-hours (GWh) of energy annually, and this does not even include interior building lighting (Winner & Arnold, 2015). Efficiency in the lighting sector is crucial when considering decreasing energy consumption in a community. Saratoga Springs has more than 3,000 street lights within its boundaries with 1,037 historic street lights in the historic lighting district. The majority of the historic fixtures use outdated high pressure sodium (HPS) technology. The city also owns 32 buildings that consume significant amounts of energy from inefficient fluorescent lighting. Although HPS and fluorescent fixtures may have been reliable in the past, more energy efficient and proven technologies are available. One sustainable

replacement is light emitting diode (LED) bulbs. LEDs are more efficient because they produce light directionally through a narrow band of wavelength, rather than omnidirectional light through infrared radiation. LEDs also have a much longer lifespan than its competitors. Most LEDs last 50,000 to 70,000 hours, while fluorescents and HPSs only last 15,000 to 25,000 (Yam & Hassan, 2005). Although they are more expensive than other lamps, LEDs have lower maintenance costs and save energy, so the long-term savings are high. In fact, if New York state were to replace all its municipal street lights with LED technology, there would be annual savings of 524 GWh of energy, $67 million in maintenance costs, and $28 million in financial savings. The total annual savings potential is estimated to be over $97 million and more than 100,000 metric tons of CO_2 equivalent (MT eCO_2) (Winner & Arnold, 2015). Saratoga Springs could also experience high financial and environmental savings from LED conversion.

Saratoga Springs has also become one of the fastest growing communities in the New York capital region. The city attracts thousands of tourists in the summer months due to the track season and other leisure activities. As a result, there is a great flow of motor vehicles through the city. This has elevated carbon dioxide emissions and deteriorated air quality in the region. Implementing more electric vehicle (EV) charging stations would encourage efficient vehicle use in the area and alleviate air degradation caused by vehicle greenhouse gas emissions. Furthermore, Saratoga Springs, has experienced increases in the number of electric vehicle registrations. For example, the number of electric vehicle registrations increased by nearly 5,500 from 2017 to 2018. The community requires more public charging locations to accommodate the growth of electric vehicle use and to decrease their carbon footprint. The implementation of LED lighting in both the city building indoor lights and historic street lights, as well as the installation

of new EV charging stations will increase the energy efficiency and decrease the greenhouse gas emissions of Saratoga Springs, while also expanding the sustainability portfolio of the city.

Methods

Energy Benchmarking of City Properties:

Saratoga Springs has been reporting the energy consumption of city buildings with the Energy Star Portfolio since late 2016. These reports list the total electricity and natural gas consumption for the city's largest properties. Saratoga Springs currently has 32 city buildings listed in the Energy Star Portfolio. The 2018 electricity consumption of each building had to be calculated in order to identify which properties the indoor LED lighting project would focus on. The annual electricity consumptions were calculated using monthly electricity bills and it was decided that the focus would be on the Weibel and Vernon Ice Rinks (Saratoga Ice Rinks), Recreation Center, and the Lake Avenue and West Avenue Fire Stations. The Saratoga Ice Rinks were chosen because the Water Treatment Plant uses the majority of its electricity for water filtration technology, rather than lighting. The Recreation Center was chosen because the Saratoga City Center and City Hall have included or are including LED lighting in renovations. Finally, the Lake Avenue and West Avenue Fire Stations were chosen because the Saratoga Springs Fire Department expressed interest in having the stations evaluated for LED lighting.

Indoor Lighting LED Replacements:

Fluorescent lights were counted in the Weibel and Vernon Ice Rinks, Recreation Center, and Lake Avenue and West Avenue Fire Stations. The Saratoga Springs Senior Electrician, Dan Rancour, assisted with the identification of the existing fluorescents through Grainger, Inc. where the city purchases the majority of their lights from. This information was shared with Karl

Pedersen, the Director of Energy Services of Wolberg Electric Supply in Albany. Based on the model of the fluorescents, Mr. Pedersen provided LED lamp replacements and ballasts for each of the existing models. Grainger provides discounted prices for contracted New York State businesses, so the Senior Sales Manager of Grainger, Christopher Morris, was contacted to provide exact contract prices for all of the fluorescent and LED lamps.

Historic Street Lighting LED Replacements:

Research began by focusing on improvements other cities have made to their historical street lighting. This research narrowed the scope of the project to the street light fixtures inside Saratoga Springs' Historical Lighting District. Tina Carton, the Director of Parks, Open Space, Historic Preservation, and Sustainability at Saratoga Springs, provided information on the upfront costs of the project and possible funding opportunities through the New York State Energy Research and Development Authority (NYSERDA). Dan Rancour provided possible installation and maintenance costs of retrofitting the current HPS fixtures to the proposed LED lamps. These factors were used to determine the payback period of the LED light installations. In addition, the energy consumption of the street lighting had to be converted from unmetered to metered with the help of the Deputy Commissioner of Finance at Saratoga Springs, Mike Sharp, in order to calculate total savings.

Financial Analyses of LED Replacements:

The following calculations apply to the LED replacements for city building indoor lighting and historic street lighting. The bulb model, number of bulbs, total wattage per bulb, and annual usage hours per bulb were calculated and used to determine the total electricity consumption (kWh) for each bulb model. These specifications for the street lights were provided by Christina Carton and Dan Rancour. The annual usage hours for the Recreation Center were

also provided by Dan Rancour and the usage hours for both the fire stations were provided by Lieutenant Aaron Dyer. The annual usage hours for Weibel and Vernon Ice Rink were calculated based on the 2018 rink schedules provided by the Saratoga Springs Recreation Department. Annual kilowatt hours were calculated with the following equation:

$$\left[\frac{Total\ Wattage\ (W)}{1000}\right] \times Annual\ Usage\ Hours$$

The annual cost of electricity was calculated by multiplying the annual kilowatt hours by the cost per kilowatt hour. The cost per kilowatt hour was determined with National Grid bills. All of these calculations were applied for the existing fluorescents and proposed LEDs for the street lights and each of the studied buildings. The annual electricity consumption and annual cost of electricity consumption savings from LED replacements were then calculated.

The product of the financial analyses for both lighting projects are the payback periods of replacing the existing fluorescent and HPS bulbs with the proposed LEDs. The payback periods were identified by calculating the net present value of the total cash flows associated with the LED replacements. In order to calculate the net present value, the upfront capital cost, annual electricity savings, and annual replacement and labor savings had to be determined. The capital cost was calculated by finding the cost difference of purchasing the proposed lamps over the current lamps. The annual electricity savings were determined by multiplying the annual cost of electricity consumption by a predetermined inflation rate of 3.5 percent. The annual replacement and labor savings were determined with the following equation:

$$\left(\frac{Total\ Cost\ of\ Fluorescent\ or\ CFL + \ Labor\ Cost}{Lifespan\ of\ Fluorescents\ or\ CFL}\right) - \left(\frac{Total\ Cost\ of\ LEDs + Labor\ Cost}{Lifespan\ of\ LEDs}\right)$$

Regarding the indoor lighting, the above labor cost assumed a wage of $35 per hour, two employees, and the number of hours required to replace the lighting in each building. The

Recreation Center and both fire stations will require two days to replace all of the fluorescents with LEDs and the Saratoga Ice Rinks will require three days. Regarding the historic street lighting, the labor costs also assumed a wage of $35 per hour, but only one employee and 20 minutes to replace the bulb in each fixture. The $1,100 labor cost of rewiring the historic light fixture was added to the upfront capital cost, rather than the labor cost in the annual replacement and labor savings calculation. Finally, the average lifespan of the bulbs was determined by dividing the rated life of the lamp by its annual usage hours. The inflation rate of 3.5 percent was applied to the annual replacement and labor savings.

The total cash flows each year were determined using the sum of the upfront capital cost, annual electricity savings, and annual replacement and labor savings. The upfront capital cost was only applied to the first year. The annual electricity savings were applied every year. The annual replacement and labor savings were applied two years after the LEDs were installed. The total cash flows were then adjusted to net present value. The first year to experience a positive net present value is the payback period. These calculations were applied to the historic street lights and the Saratoga Ice Rinks, Recreation Center, and Lake Avenue and West Avenue Fire Stations.

Two financial analysis scenarios were calculated for the historic street lights and each city property. The first scenario involved no New York State incentives, while the second scenario included them. Regarding the historic street lighting, the incentive applied was a $50,000 grant from NYSERDA. Regarding the city building indoor lighting, the incentives applied were the National Grid Customer Directed Option (CDO) Small Business Energy Efficiency Program and the National Grid 2019 Retrofit Program for Lighting Systems & Controls. The CDO Program applies to businesses that have an annual energy demand of less

than 110 kW and provides rebates of up to 60 percent of the total cost of LED upgrades (National Grid, 2018). The 60 percent reduction was applied to the upfront capital cost of the Recreation Center and both fire stations. The Retrofit Programs is for businesses with an annual demand greater than 110 kW and provides predetermined incentives of up to 50 percent of the total LED upgrade cost (National Grid, 2019). The Saratoga Ice Rinks received this 50 percent reduction of the upfront capital cost. These incentives did not change any other financial analysis variables other than the upfront capital cost.

Electric Vehicle Charging Stations:

Analysis of the existing EV charging stations located throughout Saratoga Springs and Skidmore College, lead to this study working with the ChargePoint CT4000 Dual Port charging station. Communications with Tina Carton, town planners, business owners, and sustainability coordinators provided information on the ChargePoint station, such as the necessary electrical input, hardware, and electronic software. Monthly ChargePoint usage data for the existing charging stations at the Woodlawn Avenue Garage and the Walton Street Garage was analyzed to calculate the annual EV charging station demand and electricity consumption.

It was decided that three new stations would be installed at locations that directly related to the indoor and street lighting portions of the project. They will be installed near City Hall in the historic lighting district and at the Saratoga Ice Rinks and Recreation Center. Saratoga Springs' existing and proposed EV charging stations were mapped using Skidmore College Library GIS software (Appendix Figure 17). Finally, a mock-up of educational signage to be installed on the charging stations was created.

Financial Analysis of Electric Vehicle Charging Stations:

Similarly to the lighting projects, the financial analysis calculations produce a payback

period for the EV charging stations through the net present value of the total cash flows. The annual cash flows are determined by the upfront capital costs, incentives, operating costs, and annual revenue of the stations. The upfront capital cost includes the price per charging station, installation costs, and price of the marketing signs. The operating costs cover the price of the database software used by ChargePoint to record the demand and electricity consumption of the stations. Both of these variables were determined through various invoices from Tina Carton and communication with ChargePoint, Inc. The annual revenue was calculated for each station by multiplying the annual energy consumption of the Woodlawn Avenue Garage by a $0.15 per kWh charged fee. This charging fee was chosen because it is the average price homeowners pay for residential electricity in Saratoga Springs. The incentives, which were applied to one financial analysis scenario, are the NYSERDA Charge Ready NY Program and the National Grid Complimentary Program. The NYSERDA grant provides $4,000 per electric vehicle station and the National Grid grant covers the entire installation costs of each station. Combining the capital costs, incentives, operating costs, and annual revenue provided the annual cash flows for the project. Converting the cash flows into net present value determined the payback period for EV charging station installations.

Greenhouse Gas Analyses:

The greenhouse gas analysis was calculated using the Campus Carbon Calculator from the University of New Hampshire. The spreadsheet provides the electricity fuel mix for New York which includes 38 percent natural gas, 30 percent nuclear energy, 20 percent hydro-electric, 6 percent residual oil, and the remaining 6 percent a combination of biomass, wind, solar, and coal. Based on these electricity sources, the spreadsheet calculates the total metric tons of CO_2 equivalent when the kilowatt hours are input into the formula. Regarding indoor and

historic street lighting, this was done using the annual kilowatt hours for the existing fluorescents and proposed LEDs for each building.

Regarding the electric vehicle charging stations, the total kilowatt hours were determined from the Woodlawn Avenue Garage station's energy demand. This number was applied to each proposed EV charging station. The greenhouse gas emissions savings from electric vehicles was calculated by determining the average MT eCO_2 emitted for each gallon of gas an electric vehicle will save.

Results

Energy Benchmarking of City Properties:

The buildings that are the most electricity intensive in the city are the Marion Avenue Water Treatment Plant, Weibel and Vernon Ice Rinks, Saratoga City Center, Saratoga Springs City Hall, Recreation Center, and Geyser Crest Water Treatment Lab Facility (Figure 1). In 2018 the city consumed 6,714,697 kWh of electricity with a total cost of $528,411 (Appendix Figure 18). This study focuses on the Saratoga Ice Rinks, Recreation Center, and Lake Avenue and West Avenue Fire Stations. The Saratoga Ice Rinks, Recreation Center, and Lake Avenue and West Avenue Fire Stations account for 29% of the 2018 electricity consumption of all the city-owned properties with a total consumption of 1,946,018 kWh and a cost of $167,166 (Appendix Figure 18).

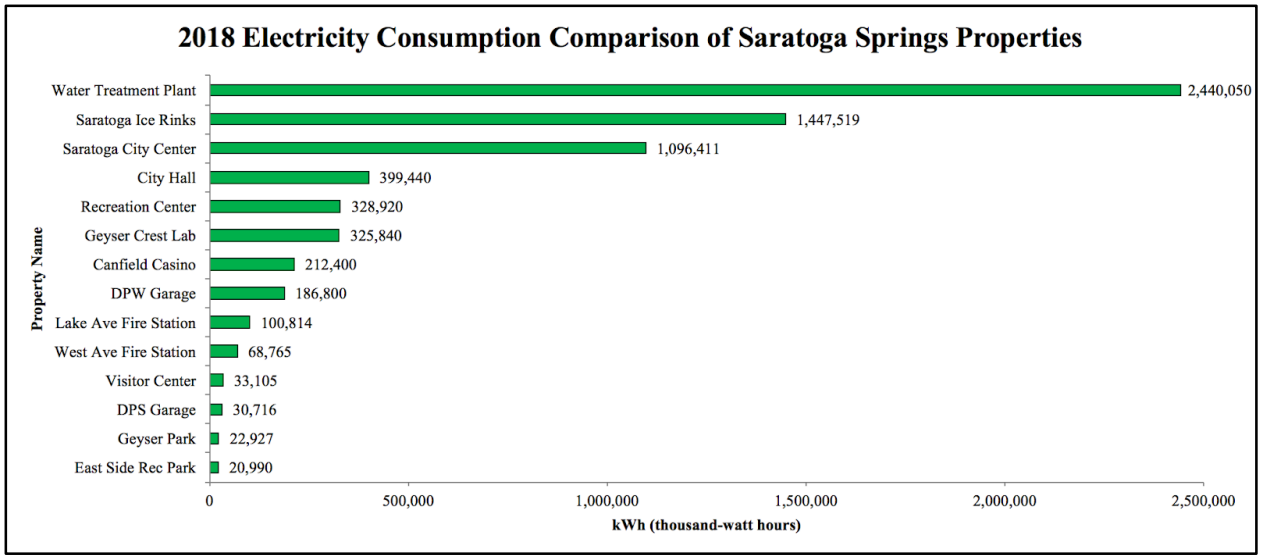


Figure 1. 2018 Electricity Consumption Comparison of All Saratoga Springs Properties

Indoor Lighting LED Replacements:

Based on the total wattage and the hours per year, the property that consumes the most annual electricity from fluorescent lighting is the Saratoga Ice Rinks with 144,912 kWh per year. This also makes the Saratoga Ice Rinks the property that spends the most on annual lighting electricity at $11,593 per year (Figure 2). Currently the Saratoga Ice Rinks, Recreation Center, and Lake Avenue and West Avenue Fire Stations consume approximately 318,443 kWh of electricity per year and spend $26,159 from fluorescent lighting alone (Figure 2).

Property Name	Current Bulb and Wattage (W)	Total Fixtures	Total Bulbs	Total Wattage (W)	Hours per Year	kWh per Year	Total kWh per Year	Cost per kWh	Cost of kWh per Year	Total Cost of kWh per Year
Weibel Ice Rink	T5 54W Fluorescent	36	360	19440	3,927	76340.88		$0.08	$6,107.27	
	T8 32W Fluorescent	44	82	2624	3,927	10304.45		$0.08	$824.36	
	T12 35W Fluorescent	3	6	210	3,927	824.67	87470.00	$0.08	$65.97	$6,997.60
Vernon Ice Rink	T5 54W Fluorescent	56	224	12096	3,989	48250.94		$0.08	$3,860.08	
	T8 32W Fluorescent	18	72	2304	3,989	9190.66	57441.60	$0.08	$735.25	$4,595.33
Recreation Center	T5 54W Fluorescent	48	288	15552	5,012	77946.62		$0.08	$6,235.73	
	T8 32W Fluorescent	78	146	4672	5,012	23416.06		$0.08	$1,873.29	
	T4 26W Fluorescent	28	28	728	5,012	3648.74	105011.42	$0.08	$291.90	$8,400.91
Lake Ave Fire Station	T8 25W Fluorescent	96	167	4175	7,300	30477.50		$0.09	$2,742.98	
	T12 40W Fluorescent	1	4	160	3,650	584.00	31061.50	$0.09	$52.56	$2,795.54
West Ave Fire Station	T8 25W Fluorescent	50	111	2775	7,300	20257.50		$0.09	$1,823.18	
	T8 25W Fluorescent	35	70	1750	3,650	6387.50		$0.09	$574.88	
	T12 40W Fluorescent	23	74	2960	3,650	10804.00	37449.00	$0.09	$972.36	$3,370.41

Figure 2. Annual Electricity Consumption and Cost from Existing Fluorescent Lighting in Saratoga Springs Properties

The LED bulbs listed in Figure 3 are the proposed replacements for the fluorescents listed in Figure 2. Figures 19 to 23 in the Appendix provides the specifications of each existing bulb and its replacement for each city building. The Saratoga Ice Rinks remain the largest consumer of annual electricity with 64,210 kWh annually from LED lamps. They are also spending the most on annual electricity after LED installations with $5,136.76 per year (Figure 3). After LED lamps are installed, the Saratoga Ice Rinks, Recreation Center, and Lake Avenue and West Avenue Fire Stations will consume 135,986 kWh per year and spend $11,136 (Figure 3).

Property Name	Proposed Bulb and Wattage (W)	Total Fixtures	Total Bulbs	Total Wattage (W)	Hours per Year	kWh per Year	Total kWh per Year	Cost per kWh	Cost of kWh per Year	Total Cost of kWh per Year
Weibel Ice Rink	T5 24W LED	36	360	8640	3,927	33929.28		$0.08	$2,714.34	
	T8 14W LED	44	82	1148	3,927	4508.20		$0.08	$360.66	
	T8 13W LED	3	6	78	3,927	306.31	38743.78	$0.08	$24.50	$3,099.50
Vernon Ice Rink	T5 24W LED	56	224	5376	3,989	21444.86		$0.08	$1,715.59	
	T8 14W LED	18	72	1008	3,989	4020.91	25465.78	$0.08	$321.67	$2,037.26
Recreation Center	T5 24W LED	48	288	6912	5,012	34642.94		$0.08	$2,771.44	
	T8 14W LED	78	146	2044	5,012	10244.53		$0.08	$819.56	
	PL 8.5W LED	28	28	238	5,012	1192.86	46080.33	$0.08	$95.43	$3,686.43
Lake Ave Fire Station	T8 10W LED	96	167	1670	7,300	12191.00		$0.09	$1,097.19	
	T8 10W LED	1	4	40	3,650	146.00	12337.00	$0.09	$13.14	$1,110.33
West Ave Fire Station	T8 10W LED	50	111	1110	7,300	8103.00		$0.09	$729.27	
	T8 10W LED	35	70	700	3,650	2555.00		$0.09	$229.95	
	T8 10W LED	23	74	740	3,650	2701.00	13359.00	$0.09	$243.09	$1,202.31

Figure 3. Annual Electricity Consumption and Cost from Proposed LED Lighting in Saratoga Springs Properties

The total electricity savings Saratoga Springs would experience after replacing the fluorescents in all of the studied properties with LEDs is 182,448 kWh per year. This is a decrease of 57 percent (Figure 4). The property that will have the greatest percent decrease in electricity consumption is the West Avenue Fire Station. The West Avenue Station will decrease its annual usage by 64 percent from 37,449 kWh to only 13,359 kWh from LED replacements (Figure 4). This is a result of the station having more inefficient T12 fluorescents. The Recreation Center and Saratoga Ice Rinks will both decrease their consumption by 56 percent, while the Lake Avenue Fire Station will decrease by 40 percent (Figure 4). Expenditures on annual electricity from lighting will also decrease from $26,160 per year to $11,136 per year.

This is an annual cost saving of more than $15,000. Appendix figures 24 and 25 provide more detailed calculations regarding electricity and cost savings for these properties.

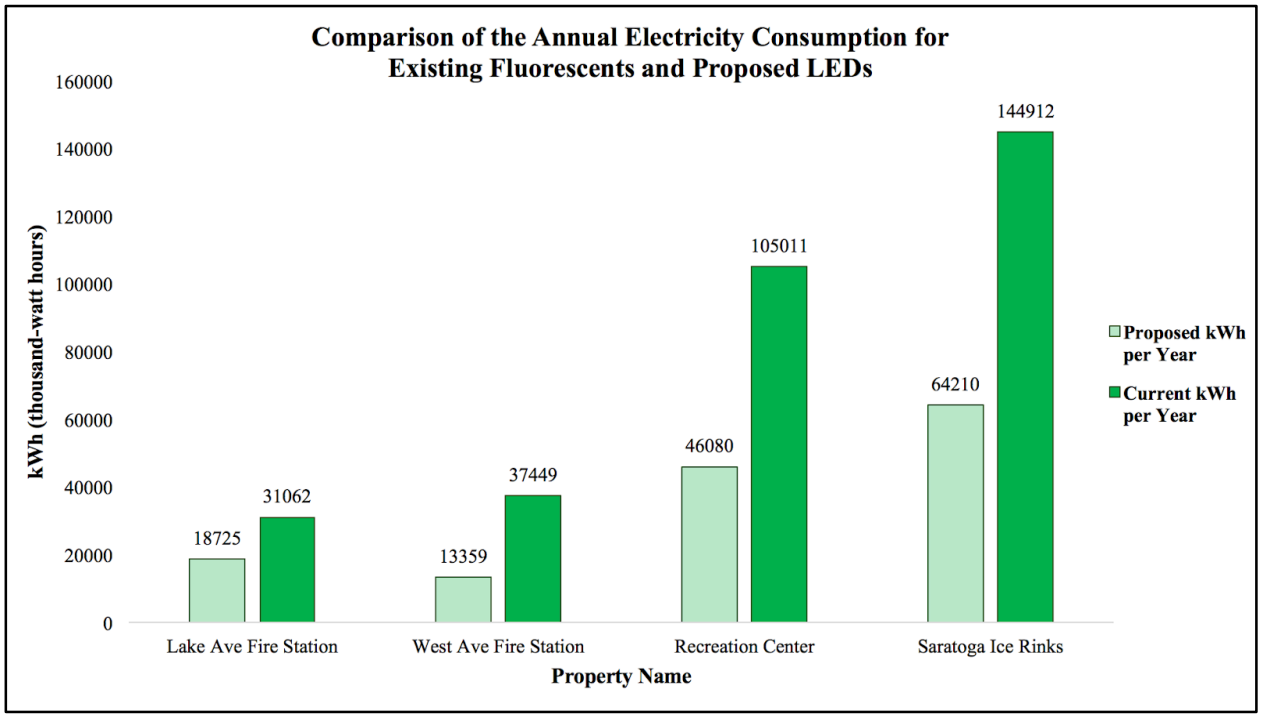


Figure 4. Comparison of the Annual Electricity Consumption of Existing Fluorescents and Proposed LEDs in Saratoga Springs Properties

Indoor Lighting LED Financial Analysis:

The first financial analysis scenario does not include any incentives for the LED project. Regardless, the upfront capital cost of purchasing the LED lamps is less than the annual electricity savings the city will experience from upgrading their lighting. Saratoga Springs will be investing approximately $11,612 in LED purchases, but will be saving $3,411 more in total energy consumption savings (Figure 5). The Saratoga Ice Rinks and Recreation Center will have negative replacement and labor savings for greater than ten years, while the Fire Stations will see positive savings almost immediately. This is a result of the significantly greater amount of lights in the Ice Rinks and Recreation Center. In the end, every property will pay off their initial LED

investment in at most one year. After ten years, Saratoga Springs will save $132,949 from replacing all of the studied properties with LED lighting (Figure 5).

Property Name	Upfront Capital Cost	Annual Electricity Savings	Annual Replacement & Labor Savings	Payback Period	Total Savings in 10 Years
Saratoga Ice Rinks	$5,690.00	$6,456.00	-$87.00	1 Year	$56,248.00
Recreation Center	$4,171.00	$4,714.00	-$253.00	1 Year	$39,693.00
Lake Ave Fire Station	$572.00	$1,685.00	$66.00	1 Year	$16,206.00
West Ave Fire Station	$1,179.00	$2,168.00	$138.00	1 Year	$20,802.00
Totals	**$11,612.00**	**$15,023.00**	**-$136.00**	**1 Year**	**$132,949.00**

Figure 5. Financial Analysis of LED Indoor Lighting Replacements without Incentives in Saratoga Springs Properties

The second financial analysis scenario includes the National Grid CDO Program and the National Grid 2019 Retrofit. These incentives decrease the upfront capital cost for each building by $8,819 and increase the total savings for the entire project to $147,090. The payback period for every studied property remains at only one year (Figure 6).

Property Name	Upfront Capital Cost	Annual Electricity Savings	Annual Replacement & Labor Savings	Payback Period	Total Savings in 10 Years
Saratoga Ice Rinks	$1,508.00	$6,456.00	$212.00	1 Year	$62,450.00
Recreation Center	$1,043.00	$4,714.00	$60.00	1 Year	$44,979.00
Lake Ave Fire Station	$170.00	$1,685.00	$117.00	1 Year	$17,292.00
West Ave Fire Station	$72.00	$2,168.00	$207.00	1 Year	$22,369.00
Totals	**$2,793.00**	**$15,023.00**	**$596.00**	**1 Year**	**$147,090.00**

Figure 6. Financial Analysis of LED Indoor Lighting Replacements with Incentives in Saratoga Springs Properties

<u>Indoor Lighting LED Greenhouse Gas Analysis</u>:

Based on the formulas provided by the Campus Carbon Calculator from the University of New Hampshire, Saratoga Springs will experience large greenhouse gas emissions from replacing LED lighting in all four of the properties. The Saratoga Ice Rinks will see the greatest savings of 15.6 MT eCO_2. In total, Saratoga Springs will decrease their emissions by 57 percent from 61.4 MT eCO_2 to 26.3 MT eCO_2 (Figure 7).

Property Name	Fluorescents GHG Emissions per Year (MT eCO2)	LED GHG Emissions per Year (MT eCO2)	Saved GHG Emissions (MT eCO2)
Saratoga Ice Rinks	28.0	12.4	15.6
Recreation Center	20.2	8.9	11.3
West Ave Fire Station	7.2	2.6	4.6
Lake Ave Fire Station	6.0	2.4	3.6
Totals	**61.4**	**26.3**	**35.1**

Figure 7. Greenhouse Gas Analysis of LED Indoor Lighting Replacements in Saratoga Springs Properties

Historic Street Lighting LED Replacements:

Three different HPS bulb wattages, 150W, 100W, and 96W, that varied throughout the historic street lights were identified. These HPS lamps were matched to LED bulbs with 96W, 64W, and 53W. This created a total of three different groups of lighting fixtures considered in the study: 150W HPS to 96W LED, 100W HPS to 64W LED, and 70W HPS to 53W LED (Figures 8 & 9).

Currently the total electricity consumption by all of the HPS street lights is 441,767 kWh per year with a total cost of $35,341. The 100W HPS bulbs consume the most annual electricity with 228,198 kWh per year. This also makes the 100W HPS bulbs the fixtures that spend the most on annual electricity at $18,256 per year. These amounts account for more than 50 percent of the total electricity consumption and cost of all the HPS street lights (Figure 8).

Current HPS Bulb Wattage (W)	Catolog Number	Total Bulbs	Usage Hours per Year	kWh per Year	Cost per kWh	Cost of kWh per Year
150	2AVD7	158	4380	103806	$0.08	$8,304
100	2AVD5	521	4380	228198	$0.08	$18,256
70	2AVD4	358	4380	109763	$0.08	$8,781

Figure 8. Annual Electricity Consumption and Cost from Existing HPS Historic Street Lighting

After the replacement of the current bulbs with LED alternatives, the total electricity consumption by street lighting will be 295,589 kWh per year with a total cost of $23,647 for Saratoga Springs. The 64W LED replacement for the 100W HPS lamp will still experience the

greatest electricity demand with 146,047 kWh per year. The 64W LED will also spend the most on electricity from street lighting after LED installations with $11,684 annually (Figure 9).

Proposed LED BulbWattage (W)	Catalog Number	Total Bulbs	Usage Hours per Year	kWh per Year	Cost per kWh	Cost of kWh per Year
96	A850SRLED 5T 6ARC22T5 MDL03	158	4380	66436	$0.08	$5,315
64	D650SRLED 5T 4ARC22T5 MDL03	521	4380	146047	$0.08	$11,684
53	A850SRLED 5T 3ARC22T5 MDL03	358	4380	83106	$0.08	$6,648

Figure 9. Annual Electricity Consumption and Cost from Proposed LED Historic Street Lighting

The total electricity savings Saratoga Springs will experience after replacing all the HPS light fixtures with LED lamps is 146,178 kWh per year. This is a total decrease of 33 percent (Figure 10). The fixtures that will have the greatest percent decrease in electricity consumption are the 150W and 100W HPS lamps. These lamps will decrease their annual usage by 36 percent from LED replacements. The 70W HPS fixtures will decrease their electricity consumption by 24 percent from 109,763 per year to 83,106kWh per year (Figure 10). Expenditures on annual electricity will also decrease from $35,341 per year to $23,647 per year. This is an annual savings of $11,694 for Saratoga Springs. Figure 26 provides more details about electricity consumption and cost savings from LED replacements in the historic street light fixtures.

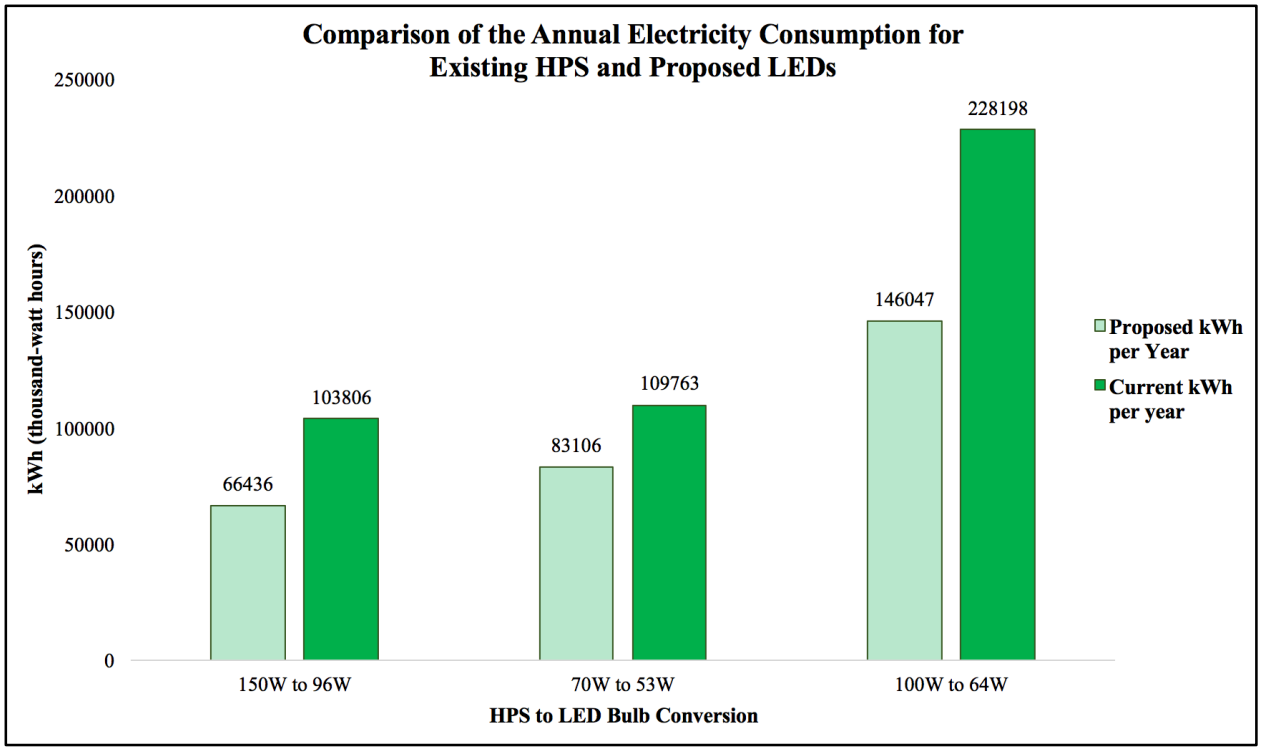


Figure 10. Comparison of the Annual Electricity Consumption of Existing HPS and Proposed LED Historic Street Lighting

Historic Street Lighting LED Financial Analysis:

The first financial analysis scenario focuses on replacing all of the historical fixtures in Saratoga Springs. The upfront capital cost of of replacing all of the lighting fixtures is upwards of $1 million with and without the $50,000 grant from NYSERDA (Figure 11). This is a result of the extensive $1,100 replacements necessary for each fixture. The annual electricity savings and replacement and labor savings are significantly lower than the upfront capital costs. This produces a payback period of greater than 10 years (Figure 11).

Number of Replaced Bulbs	NYSERDA Grant	Upfront Capital Cost	Annual Electricity Savings	Annual Replacement & Labor Savings	Payback Period
1,037	Not Included	$1,140,700	$11,678	$2,392	> 10 Years
1,037	Included	$1,090,700	$11,678	$2,392	> 10 Years

Figure 11. Financial Analysis of LED Replacements in 1,037 Historic Street Lights

The financial analysis in Figure 11 was not positive, so a second scenario in which only 50 of the 150W HPS lamps are replaced. This decreased the upfront capital cost to $55,000 without the NYSERDA grant and $5,000 with the grant. The annual electricity savings and annual replacement and labor savings also decreased as a result of the change in replaced bulbs. Without the grant, updating 50 150W HPS fixtures will still have a payback period longer than 10 years, but with the grant the payback period is only six years and the total savings are $2,307 after ten years (Figure 12).

Number of Replaced Bulbs	NYSERDA Grant	Upfront Capital Cost	Annual Electricity Savings	Annual Replacement & Labor Savings	Payback Period
50	Not Included	$55,000	$946	-$278	> 10 Years
50	Included	$5,000	$946	-$278	6 Years

Figure 12. Financial Analysis of LED Replacements in 50 Historic Street Lights

Historic Street Lighting LED Greenhouse Gas Analysis:

Converting all of the Sternberg fixtures to LEDs will decrease the greenhouse gas emissions of Saratoga Springs by 26.4 MT eCO_2. In the second scenario, 2.1 MT eCO_2 will be saved from updating 50 of the light fixtures.

Electric-Vehicle Charging Stations:

Based on the usage data from ChargePoint, the Woodlawn Avenue Garage charging station provided 8,339 kWh of electricity to electric vehicles from February 2018 to February 2019. The months that experienced the highest demand were August, September, and October (Figure 13).

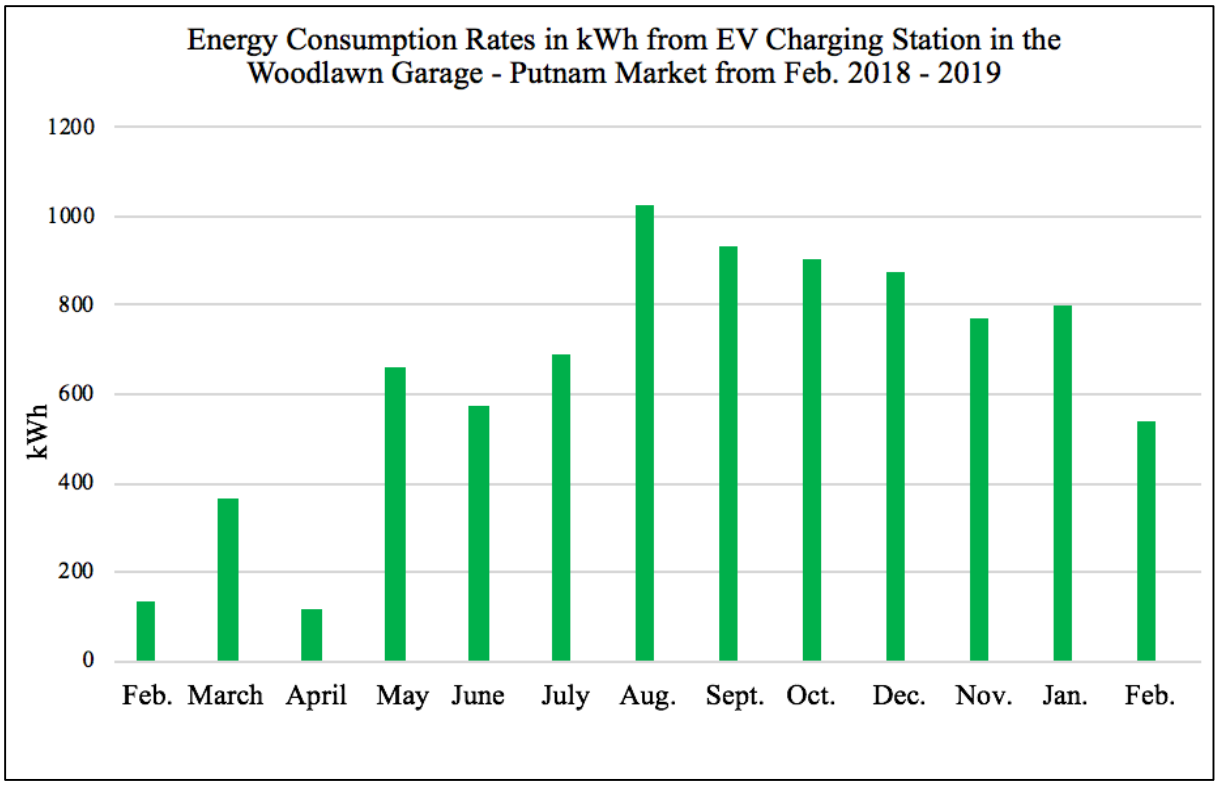


Figure 13: 2018 Energy Usage Data from the Woodlawn Avenue Garage ChargePoint Charging Station

The second city-owned charging station in the Walton Street Garage has only been online for five months, however this charging station consumed upwards of 2,600 kWh from October to February of 2018. January experienced the greatest demand (Figure 14).

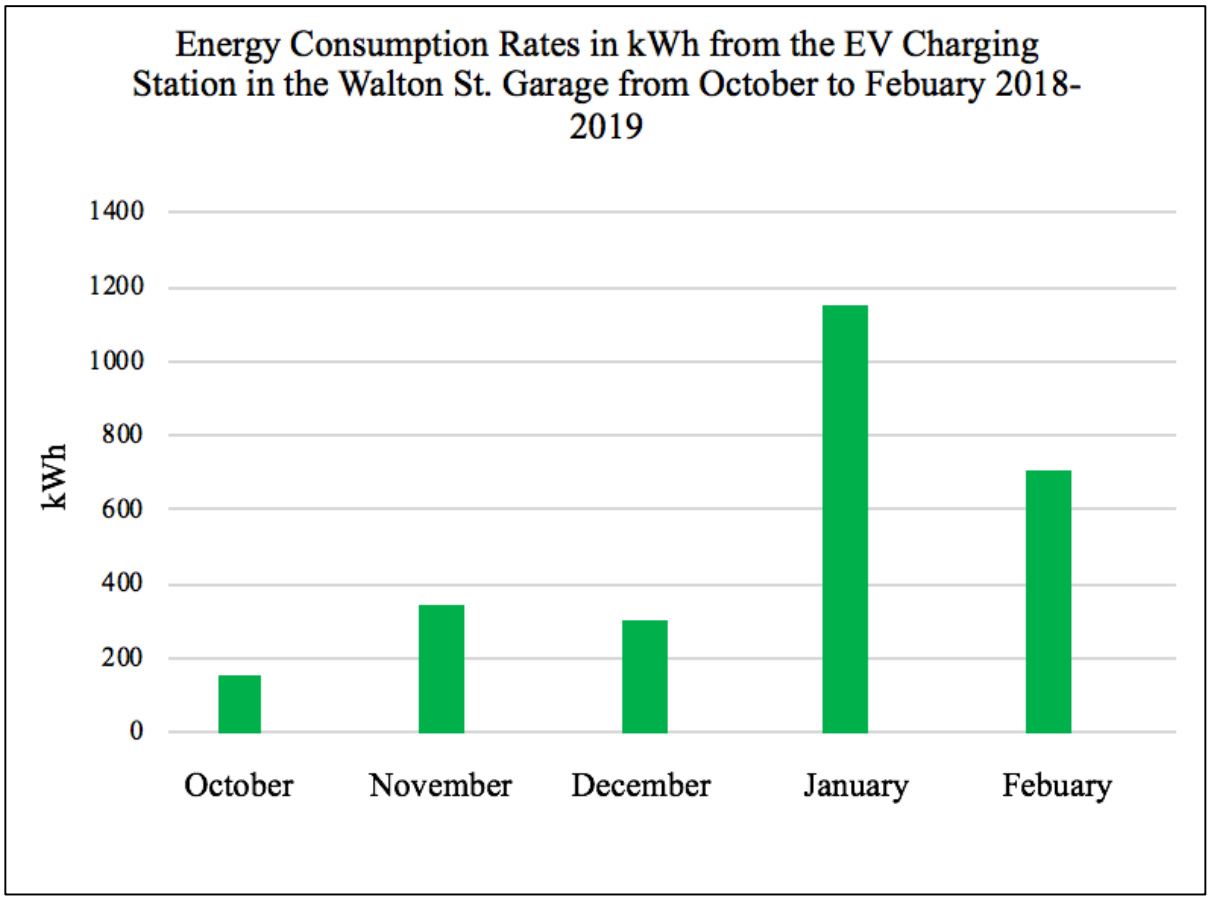


Figure 14: Energy Usage Data from the Walton St. Garage ChargePoint Charging

Electric-Vehicle Charging Stations Financial Analysis:

The first financial analysis scenario does not include any incentives for the EV charging stations. The upfront capital cost is high at $21,552 for purchasing and installing the three charging stations and the associated signage. The $0.15 fee to charge applied to each station produces a revenue of $1,251 per year, but the high initial investment creates a payback period of more than 10 years (Figure 15). The second scenario includes the $4,000 per charging station grant from NYSERDA and the National Grid grant, which covers the entire installation cost of each station. These incentives decrease the upfront capital cost by $15,600 and change the payback period to six years. After ten years with the second scenario, Saratoga Springs will save more than $2,000 (Figure 15).

Incenitves	Upfront Capital Cost	Operating Costs	Annual Revenue	Payback Period
Not Included	$21,552.00	$749.88	$1,250.78	> 10 Years
Included	$5,952.00	$749.88	$1,250.78	6 Years

Figure 15: Financial Analysis of EV Charging Stations based on Incentives

Electric-Vehicle Charging Stations Greenhouse Gas Analysis:

Based on the average vehicle emissions saved from the average electric vehicle, the three proposed charging stations will decrease Saratoga Springs' greenhouse gas emissions by approximately 45 MT eCO_2.

Electric Vehicle Charging Stations Signage:

Figure 16 is the proposed signage to be installed on the EV charging stations. The marketing sign will highlight the financial and environmental benefits of owning an electric vehicle as well as information about the LED lighting initiatives and other sustainable projects implemented by Saratoga Springs. The sign will work to educate the community about sustainability in the city (Figure 16).

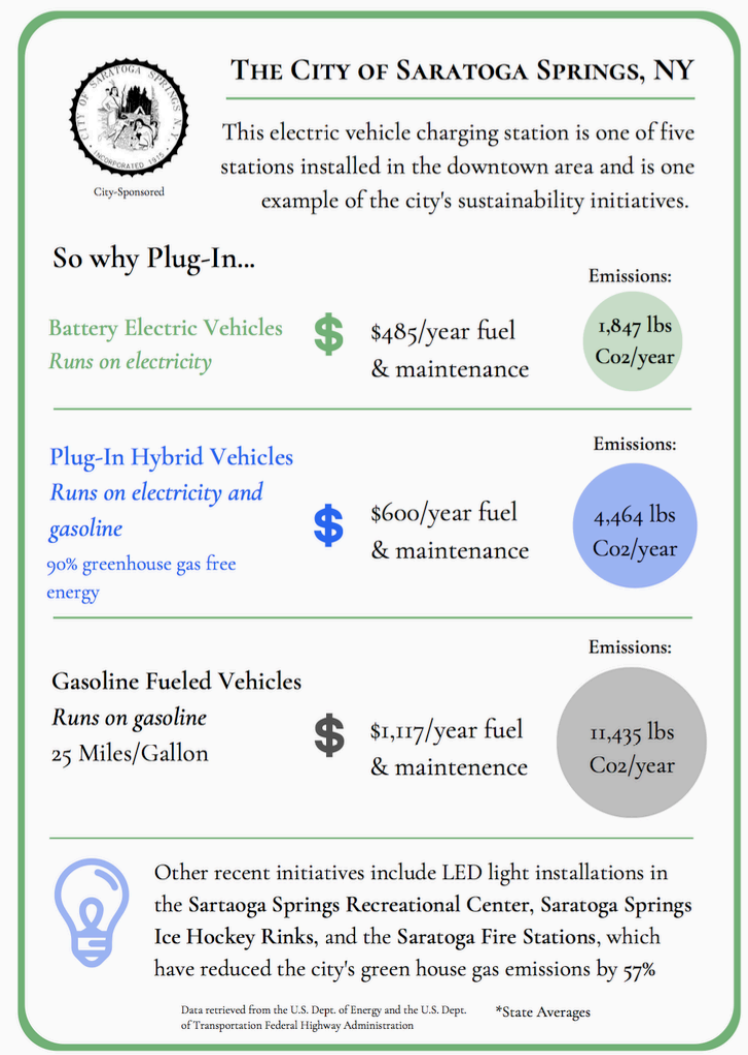


Figure 16: Example of Signage for the proposed EV Charging Stations in Saratoga Springs, NY

Discussion

Saratoga Springs has been consistently making efforts to decrease their carbon footprint through various sustainability projects, but the city's electricity consumption remains high. In 2018, the city's major buildings consumed more than 6.7 million kWh of electricity and this does not include energy demand from street lighting, commercial spaces, or residential spaces (Appendix Figure 18). If the city's historic street lighting is added, annual electricity

consumption increases to nearly 6.9 million kWh. This is a result of outdated fluorescent and HPS bulbs being used in city buildings and historic street light fixtures, respectively. In order to decrease their high electricity demand, Saratoga Springs should install efficient LED technology in both the historic street fixtures and indoor lighting.

Indoor Lighting LED Replacements:

The LED lamp replacements provided by Wolberg Electric Supply are seven Philips InstantFit LED lamps to be installed in the four city properties (Appendix Figures 19-23). The base of these LED lamps are compatible with more than 200 ballasts, including those of the fluorescent fixtures, so the majority of the ballasts in the city buildings will not need to be replaced (Philips, 2019). The older T12 fluorescent lamps in the Lake Avenue and West Avenue Fire Stations are not compatible with the InstantFit lamps, so new ballasts will need to be purchased and installed (Figure 27). This added cost was included in the upfront capital costs for both the financial analysis scenarios of the fire stations. Although the proposed LEDs are compatible, Saratoga Springs has the option of replacing all of its current ballasts with updated versions while installing the new LED lamps. This will prevent city employees from having to work on the fixtures again when the current ballasts eventually burn out, but will increase the upfront capital cost of the project. This cost was not included in the financial analysis. If Saratoga Springs is interested in replacing the ballasts, they should use the same brand listed for the fire stations as these are the most energy efficient and cost effective models on the market today (Figure 27).

The Saratoga Ice Rinks, Recreation Center, and Lake Avenue and West Avenue Fire Stations consume more than 318,000 kWh of electricity annually as a result of demand from fluorescent lighting alone. When the proposed LEDs are installed, the electricity consumption

from lighting in the studied properties will decrease to less than 140,000 kWh per year (Figure 4). This would decrease Saratoga Springs' total electricity consumption from 6.9 million to 6.6 million kWh per year. Electricity savings from indoor lighting alone would decrease the city's greenhouse gas emissions by 35.1 MT eCO_2 from 61.4 MT eCO_2 to 26.3 MT eCO_2. This is an emissions decrease of 57 percent for Saratoga Springs (Figure 7). Decreased energy demand will also save the city immense amounts of money in the long run. Energy cost for indoor lighting would become less expensive as a result of the high energy efficiency of the Philips InstantFit LED lamps. In fact, Saratoga Springs would save upwards of $15,000 annually on electricity bills from replacing the fluorescents in the four studied properties alone (Figure 25). These high annual electricity cost savings are ultimately what make the project so lucrative. As shown in Figures 5 and 6, not one of the upfront capital costs of purchasing the LED lights is greater than the annual electricity savings. This means Saratoga Springs will experience no negative cash flows for any of the studied buildings and will pay off their initial investment by Year 1 (Figures 5 & 6). It is important to note that the payback periods for the Saratoga Ice Rinks, Recreation Center, and both fire stations may be less than one year. It is not certain because the financial analyses were calculated annually rather than monthly, but based on a simple comparison of the upfront cost and electricity savings, it is highly likely that the four properties will see positive cash flows six to ten months after purchasing and installing the LED lamps. This timeframe will be even shorter when National Grid rebates and incentives are applied to the initial investment. In the end, Saratoga Springs will save more than $132,000 in ten years without incentives and $147,000 with incentives (Figure 5 & 6).

Based on these financial and environmental findings, it is highly suggested that Saratoga Springs replace the existing fluorescents in the Saratoga Ice Rinks, Recreation Center, and Lake

Avenue and West Avenue Fire Stations with the proposed LED lamps. It is also recommended that the city apply for the National Grid CDO Small Business Energy Efficiency Program and the National Grid 2019 Retrofit Program to increase their total financial savings. Finally, Saratoga Springs should consider replacing more of the city's buildings indoor lighting with LEDs since it is such a profitable and successful process.

Historic Street Lighting LED Replacements:

Saratoga Springs is taking steps to assess the energy efficiency of the historic street lighting fixtures in the downtown area. In the process of making the city of Saratoga Springs more energy efficient over time, electricity use and electricity costs will decrease. Calculating the conversion of the Sternberg fixtures from HPS bulbs to LED bulbs in the Historical Lighting District for our project resulted in an analysis of the potential cuts to the amount of energy used by the city, and furthermore the cost of street lighting.

Updating the Sternberg fixtures are a complex process. A key component to this update is maintaining the historic character of the city. The historic charm of Saratoga Springs' downtown area is upheld by the style of the Sternberg fixtures which line the streets. This has brought up concerns over the process of updating the fixtures. A common concern has been the kelvin temperature change when changing a fixture from a high-pressure sodium bulb to a LED bulb. The HPS bulb has a lower kelvin temperature, 2000K, creating a warm light. The concern from the city regards the cooler kelvin temperature of the LED bulb that the city has found for the Sternberg fixtures. The kelvin temperature of the LED bulb that can be found mass produced is 2700K, while the city is looking for a bulb that emits at or lower than 2200K (Carton, 2019). As a result, the Sternberg Lighting company has produced custom light bulbs for the city at 2200K. The updated kelvin temperature has preserved the historic appearance of the Sternberg fixtures,

but results in a much less energy efficient light (Carton, 2019). However, the new LED bulb still improves the energy use of the fixtures in comparison to the fixtures with the original HPS bulb.

When updating each fixture a retrofit of the ballast, driver and capacitor are completed. In addition, each fixture needs to be rewired. Due to the complexity of the retrofit and the importance of keeping the historic character to these fixtures, the upfront costs are high. The cost of retrofitting each fixture is about $1100, including three employees working three hours at the labor cost at $35 per hour. After multiplying the retrofit rate by the total fixtures that need updating, the upfront cost is significant at $1,140,700.

Although there are significant energy costs savings from replacing 1,037 street lights with LEDs, the $1 million upfront cost does not make financial sense for the city to complete the project all at once. In addition, it is made clear that the NYSERDA grant will not burden enough of the upfront cost to help the project come to fruition. Due to the restraints of the initial street lighting replacement project, the scale of the project was decreased. The NYSERDA grant does assist in the case of scaling the scope of the project down to a specific section of the historical lighting district. Focusing on a smaller area of downtown Saratoga Springs, 50 Sternberg fixtures can be replaced to create a cost savings of $946 annually for the city. For this project to work, the NYSERDA grant must be applied to the upfront costs of the lights. The energy cost savings of $946 from updating 50 Sternberg fixtures will fund more energy efficiency projects, such as future street lighting updates. The energy savings of updating the Sternberg fixtures will prove useful in providing funding for implementing sustainability initiatives down the line in Saratoga Springs.

Electric Vehicle Charging Stations:

It is important to recognize that the number of electric vehicle registrations in Saratoga Springs has continued to increase every year for the past several years. For example, the number of registered electric vehicles in Saratoga Springs nearly doubled from 2017 to 2018. We can assume that the spike in vehicle registrations comes from the consumer's decision to seek the advantages of owning an electric vehicle. This includes financial and environmental advantages. The average cost to operate an electric vehicle in 2018 came close to 500 dollars per year, while the average cost to operate a gasoline-powered vehicle was over 1000 dollars per year. For the more environmentally concerned consumers, our group highlights the fact that electric and plug-in hybrid vehicles emit significantly less amounts of carbon dioxide compared to gasoline-based vehicles. Saratoga Springs must supplement the increasing number of electric vehicles with the appropriate amount of charging stations.

Next, our group evaluated the usage data from the two-city owned ChargePoint charging stations in the Woodlawn Ave. and Walton St. Garages. Starting from February of 2018 our group found a trend of greater energy consumption rates in the late summer months to early fall for the Woodlawn Ave. Garage charging station. This aligned with our prediction of witnessing greater demand during the summer months as the city's population nearly doubles due to the track season. The Walton St. Garage had only been online for five months. However, this charging station consumed a significant amount of energy. Our group projects that this charging station will experience similar usage patterns to the Woodlawn Ave. Garage charging station.

These charging stations have the potential to offset the costs associated with installing and maintaining EV charging stations. In addition, the two incentive programs as well as the annual revenue from these charging stations will allow these three proposed stations to turn a

profit of approximately $1000.00 each consecutive year. Aside from the financial incentives, these proposed charging stations will reduce approximately 45 Metric Tons of carbon dioxide equivalents. This project provides the opportunity to bring awareness of sustainability initiatives in Saratoga Springs. As a part of our marketing campaign, our group has developed an example of signage that will be placed on the post of the charging stations to inform users as well as individuals that will walk passed the charging stations of the benefits that these stations provide. Additionally, the signs will highlight other sustainability initiatives, such as our LED lights, solar arrays and composting centers.

Green Revolving Fund:

The quintessential aspect to this project is the green revolving fund. Combining the electric vehicle charging stations, historic street lighting, and city building indoor lighting sections produces immense financial and environmental savings for Saratoga Springs. If all the recommendations are implemented, the city will save more than 106 MT eCO_2 annually and $153,826 after ten years. These savings can be funneled into a green revolving fund, which will dedicate funding to future energy efficient initiatives in Saratoga Springs. Initiatives could include continued installations of LED lighting in city buildings and historic street lighting, or other sustainable projects for the city.

Conclusion

Implementing LED lighting in the city's indoor lighting and historic street lighting, and installing new EV charging stations provide Saratoga Springs with an opportunity to expand their sustainability portfolio. The three improvement projects will increase energy efficiency, decrease expenditures on electricity consumption, and decrease greenhouse gas emissions. This

study recommends moving forward with these initiatives because of the immense financial and environmental impacts. It is recommended that Saratoga Springs apply for grants to increase their financial savings and incentivize each project. Finally, the high annual and ten-year financial savings from the three projects should be utilized for a green revolving fund. The saved cash flows from the increased energy efficiency presented by the study, will fund future sustainability programs and improvements throughout Saratoga Springs. It is necessary to implement the project because of the growing population and energy demand of Saratoga Springs.

References

Birge, B. (2015). Climate smart communities: city of Saratoga Springs. Retrieved from http://www.saratoga-springs.org/DocumentCenter/View/7176/City-of-Saratoga-Springs-Community-Profile

National Grid. (2018). Customer Directed Option Small Business Energy Efficiency Program. Retrieved from https://www1.nationalgridus.com/files/AddedPDF/POA/EE5953_ContractorCDO.pdf

National Grid. (2019). Services and Rebates. Retrieved from https://www.nationalgridus.com/Services-Rebates?filters=For%20Businesses|Upstate%20New%20York|Electric

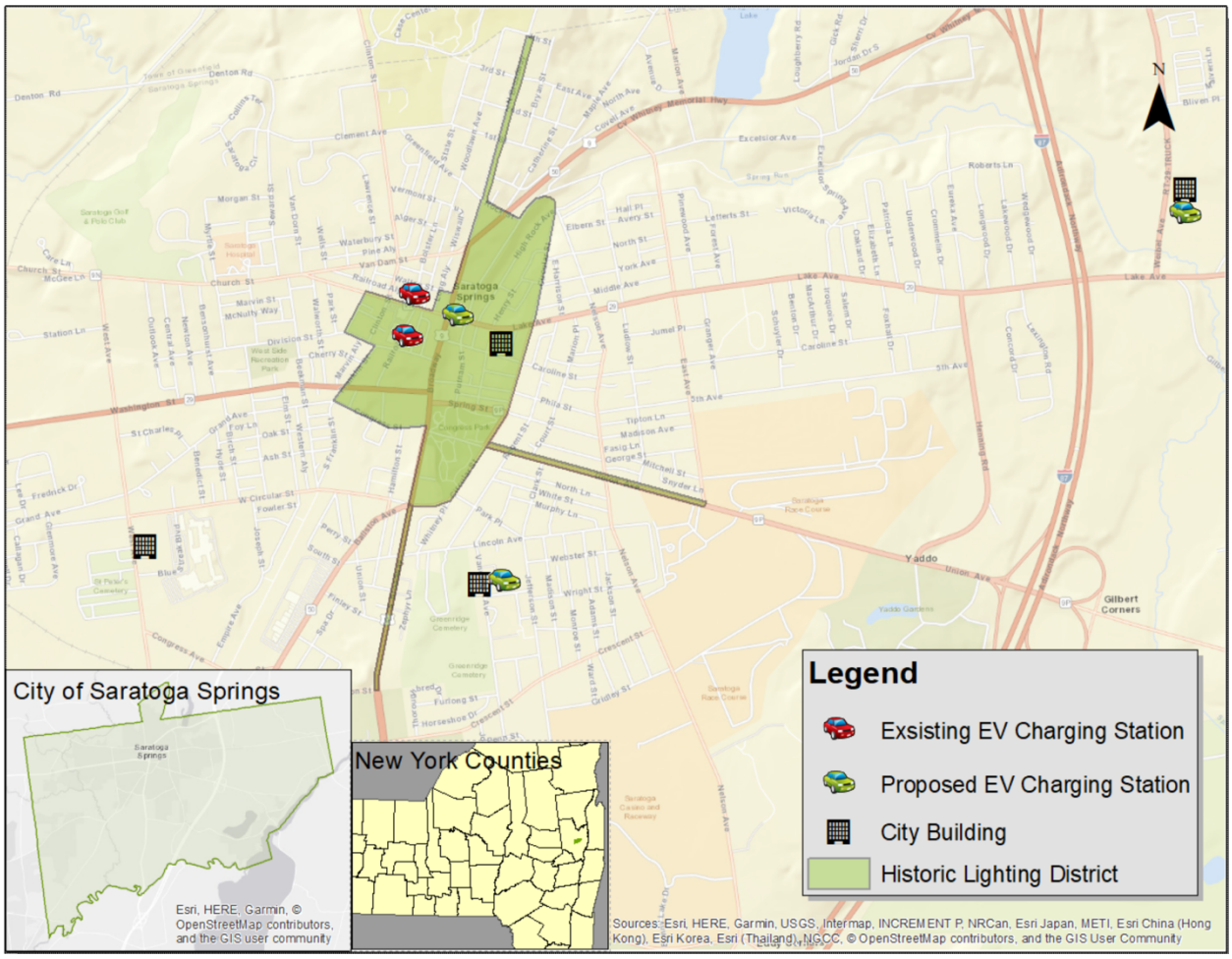
Philips. (2019). Philips InstantFit LED Lamps. Retrieved from http://www.usa.lighting.philips.com/products/product-highlights/instantfit

Winner, T., & Arnold, G. (2015, January). Street lighting in New York state: opportunities and challenges. *New York State Energy Research and Development Authority,* Report 14-42. Retrieved from https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Energy-Efficiency-Services/Street-Lighting-in-NYS.pdf

Yam, F.K., & Hassan, Z. (2005, February). Innovative advances in LED technology. *Microelectronics Journal, 36*(2), 129-137. Retrieved from https://www.researchgate.net/publication/220255633_Innovative_advances_in_LED_technology

Appendix

Figure 17. Map of Existing and Proposed Electric Vehicle Charging Stations in Saratoga Springs, NY



Property Name	2018 Annual Usage (kWh)	2018 Annual Cost
Water Treatment Plant	2,440,050	$196,912
Saratoga Ice Rinks	1,447,519	$120,449
Saratoga City Center	1,096,411	$43,434
City Hall	399,440	$38,139
Recreation Center	328,920	$30,310
Geyser Crest Lab	325,840	$28,539
Canfield Casino	212,400	$22,191
DPW Garage	186,800	$17,365
Lake Ave Fire Station	100,814	$9,395
West Ave Fire Station	68,765	$7,012
Visitor Center	33,105	$4,327
DPS Garage	30,716	$3,684
Geyser Park	22,927	$2,896
East Side Rec Park	20,990	$3,758
Totals	**6,714,697**	**$528,411**

Figure 18. 2018 Electricity Consumption and Total Electricity Cost of Saratoga Springs Properties

Location(s) in Building	Bulb Name	Grainger Item Number	Bulb Type	Base	Wattage (Watts)	Color Temp (Kelvin)	Rated Life (Hours)	Cost per Bulb with Grainer NYS Pricing per Bulb
Ice rink	GE Lighting T5 Linear Fluorescent Lamp	5AE35	Fluorescent	Miniature Bi-Pin (G5)	54	6500	36,000	$4.07
	Philips T5 Linear LED Lamp	53UG89	LED	G5	24	5000	50,000	$12.59
Lobby, skate shop, snack bar, bathrooms, ticket office	GE Lighting T8 Linear Fluorescent Lamp	18L041	Fluorescent	Medium Bi-Pin (G13)	32	3500	36,000	$1.39
	Philips T8 Linear LED Lamp	406T68	LED	G13	14	4000	50,000	$6.02
Doorway	GE Lighting T12 Fluorescent U-Tube Lamp	24W598	Fluorescent	Medium Bi-Pin (G13)	35	4100	14,000	$14.00
	Philips T8 LED U-Tube Lamp	53YZ41	LED	G13	13	4000	70,000	$14.23

Figure 19. Weibel Ice Rink Existing Fluorescents and Proposed LED Replacement Specifications

Location(s) in Building	Bulb Name	Grainger Item Number	Bulb Type	Base	Wattage (Watts)	Color Temp (Kelvin)	Rated Life (Hours)	Cost per Bulb with Grainer NYS Pricing per Bulb
Ice rink	GE Lighting T5 Linear Fluorescent Lamp	5AE35	Fluorescent	Miniature Bi-Pin (G5)	54	6500	36,000	$4.07
	Philips T5 Linear LED Lamp	53UG89	LED	G5	24	5000	50,000	$12.59
Lobby, restrooms, locker rooms	GE Lighting T8 Linear Fluorescent Lamp	18L041	Fluorescent	Medium Bi-Pin (G13)	32	3500	36,000	$1.39
	Philips T8 Linear LED Lamp	406T68	LED	G13	14	4000	50,000	$6.02

Figure 20. Vernon Ice Rink Existing Fluorescents and Proposed LED Replacement Specifications

Location(s) in Building	Bulb Name	Grainger Item Number	Bulb Type	Base	Wattage (Watts)	Color Temp (Kelvin)	Rated Life (Hours)	Cost per Bulb with Grainer NYS Pricing per Bulb
Basketball court	GE Lighting T5 Linear Fluorescent Lamp	5AE35	Fluorescent	Miniature Bi-Pin G5	54	4100	36,000	$2.45
	Philips T5 Linear LED Lamp	53UG89	LED	G5	24	4000	50,000	$12.59
Lobby, conference rooms, break room, offices, bleachers	GE Lighting T8 Linear Fluorescent Lamp	18L041	Fluorescent	Medium Bi-Pin G13	32	3500	36,000	$1.39
	Philips T8 Linear LED Lamp	449U99	LED	G13	14	3500	50,000	$7.93
Lobby	GE Lighting T4 CFL Plug-In	1PGY6	Plug-In CFL	4 Pin G24Q-3	26	3500	17,000	$4.81
	Philips LED Plug-In	44ZA57	LED	G24Q	8.5	4000	50,000	$15.39

Figure 21. Recreation Center Existing Fluorescents and Proposed LED Replacement Specifications

Location(s) in Building	Bulb Name	Grainger Item Number	Bulb Type	Base	Wattage (Watts)	Color Temp (Kelvin)	Rated Life (Hours)	Cost per Bulb with Grainer NYS Pricing per Bulb
All rooms, except Firefighter's Room and training room	Philips T8 Linear LED Lamp	492Y19	Fluorescent	Medium Bi-Pin G13	25	4100	36,000	$4.00
	Philips T8 Linear LED Lamp	406T72	LED	G13	10	4000	70,000	$7.23
Fire Fighters Room, training room	Philips T12 Linear LED Lamp	N/A	Fluorescent	Medium Bi-Pin (G13)	40	6500	13,000	$5.00
	Philips T8 Linear LED Lamp	406T72	LED	G13	10	4000	70,000	$7.23

Figure 22. Lake Avenue Fire Station Existing Fluorescents and Proposed LED Replacement Specifications

Location(s) in Building	Bulb Name	Grainger Item Number	Bulb Type	Base	Wattage (Watts)	Color Temp (Kelvin)	Rated Life (Hours)	Cost per Bulb with Grainer NYS Pricing per Bulb
All rooms in Fire Station	Philips T8 Linear LED Lamp	492Y19	Fluorescent	Medium Bi-Pin (G13)	25	4100	36,000	$4.00
	Philips T8 Linear LED Lamp	406T72	LED	G13	10	4000	70,000	$7.23
Ambulance bay, staircases, upstairs hallway	Philips T8 Linear LED Lamp	492Y19	Fluorescent	Medium Bi-Pin (G13)	25	4100	36,000	$4.00
	Philips T8 Linear LED Lamp	406T72	LED	G13	10	4000	70,000	$7.23
Day room, lower hallway, bunk rooms, bathrooms, storage rooms	Philips T12 Linear LED Lamp	N/A	Fluorescent	Medium Bi-Pin (G13)	40	6500	13,000	$5.00
	Philips T8 Linear LED Lamp	406T72	LED	G13	10	4000	70,000	$7.23

Figure 23. West Avenue Fire Station Existing Fluorescents and Proposed LED Replacement Specifications

Property Name	Current Bulb	Proposed Bulb	Current kWh per Year	Proposed kWh per Year	Saved kWh per Year	Total kWh Savings per Year	Percentage Change
Weibel Ice Rink	T5 54W Fluorescent	T5 24W LED	76340.88	33929.28	42411.60		55.6%
	T8 32W Fluorescent	T8 14W LED	10304.45	4508.20	5796.25		56.3%
	T12 35W Fluorescent	T8 13W LED	824.67	306.31	518.36	48726.22	62.9%
Vernon Ice Rink	T5 54W Fluorescent	T5 24W LED	48250.94	21444.86	26806.08		55.6%
	T8 32W Fluorescent	T8 14W LED	9190.66	4020.91	5169.74	31975.82	56.3%
Recreation Center	T5 54W Fluorescent	T5 24W LED	77946.62	34642.94	43303.68		55.6%
	T8 32W Fluorescent	T8 14W LED	23416.06	10244.53	13171.54		56.3%
	T4 26W Fluorescent	PL 8.5W LED	3648.74	1192.86	2455.88	58931.10	67.3%
Lake Ave Fire Station	T8 25W Fluorescent	T8 10W LED	30477.50	12191.00	18286.50		60.0%
	T12 40W Fluorescent	T8 10W LED	584.00	146.00	438.00	18724.50	75.0%
West Ave Fire Station	T8 25W Fluorescent	T8 10W LED	20257.50	8103.00	12154.50		60.0%
	T8 25W Fluorescent	T8 10W LED	6387.50	2555.00	3832.50		60.0%
	T12 40W Fluorescent	T8 10W LED	10804.00	2701.00	8103.00	24090.00	75.0%

Figure 24. Annual Electricity Consumption Savings from Proposed LED Replacements in Saratoga Springs Properties

Property Name	Current Bulb	Proposed Bulb	Current Cost of kWh per Year	Proposed Cost of kWh per Year	Saved Cost of kWh per Year	Total Cost Savings per Year	Percentage Change
Weibel Ice Rink	T5 54W Fluorescent	T5 24W LED	$6,107.27	$2,714.34	$3,392.93		55.6%
	T8 32W Fluorescent	T8 14W LED	$824.36	$360.66	$463.70		56.3%
	T12 35W Fluorescent	T8 13W LED	$65.97	$24.50	$41.47	$3,898.10	62.9%
Vernon Ice Rink	T5 54W Fluorescent	T5 24W LED	$3,860.08	$1,715.59	$2,144.49		55.6%
	T8 32W Fluorescent	T8 14W LED	$735.25	$321.67	$413.58	$2,558.07	56.3%
Recreation Center	T5 54W Fluorescent	T5 24W LED	$6,235.73	$2,771.44	$3,464.29		55.6%
	T8 32W Fluorescent	T8 14W LED	$1,873.29	$819.56	$1,053.72		56.3%
	T4 26W Fluorescent	PL 8.5W LED	$291.90	$95.43	$196.47	$4,714.49	67.3%
Lake Ave Fire Station	T8 25W Fluorescent	T8 10W LED	$2,742.98	$1,097.19	$1,645.79		60.0%
	T12 40W Fluorescent	T8 10W LED	$52.56	$13.14	$39.42	$1,685.21	75.0%
West Ave Fire Station	T8 25W Fluorescent	T8 10W LED	$1,823.18	$729.27	$1,093.91		60.0%
	T8 25W Fluorescent	T8 10W LED	$574.88	$229.95	$344.93		60.0%
	T12 40W Fluorescent	T8 10W LED	$972.36	$243.09	$729.27	$2,168.10	75.0%

Figure 25. Annual Electricity Cost Savings from Proposed LED Replacements in Saratoga Springs Properties

Current HPS Bulb Wattage (W)	Proposed LED BulbWattage (W)	Current kWh per Year	Proposed kWh per Year	Saved kWh per Year	Current Cost of kWh per Year	Proposed Cost of kWh per Year	Saved Cost of kWh per Year	Percent Change
150	96	103806	66436	37370	$8,304	$5,315	$2,989	36.0%
100	64	228198	146047	82151	$18,256	$11,684	$6,572	36.0%
70	53	109763	83106	26657	$8,781	$6,648	$2,133	24.3%
Total Savings	-	**441767**	**295589**	**146178**	**35341**	**23647**	**11694**	**33.1%**

Figure 26. Annual Electricity Consumption and Cost Savings from Proposed LED Replacements in Historic Street Lights

Property Name	Location in Building	Bulbs per Fixture	Total Fixtures	Ballasts	Grainger Item Number	Number of Ballasts	Price per Ballast	Cost of Ballasts	Total Cost
Lake Ave Fire Station	Int. Assoc. of Fire Fighters Room	4	1	E-Ballast 32W Max 120-277V 4 Lamp	36N040	1	$23.20	$23.20	**$23.20**
West Ave Fire Station	EMS Day Room	4	12	E-Ballast 32W Max 120-277V 4 Lamp	36N040	12	$23.20	$278.40	
	Storage Room	2	1	E-Ballast 32W Max 120-277V 2 Lamp	5PTN6	1	$19.25	$19.25	
	Bunk Room	4	2	E-Ballast 32W Max 120-277V 4 Lamp	36N040	2	$23.20	$46.40	
	Bunk Bathroom	2	1	E-Ballast 32W Max 120-277V 2 Lamp	5PTN6	1	$19.25	$19.25	
	Office/Bunk	4	2	E-Ballast 32W Max 120-277V 4 Lamp	36N040	2	$23.20	$46.40	
	Upstairs Storage Room	2	1	E-Ballast 32W Max 120-277V 2 Lamp	5PTN6	1	$19.25	$19.25	**$428.95**

Figure 27. Ballast Replacement Specifications for Lake Avenue and West Avenue Fire Stations