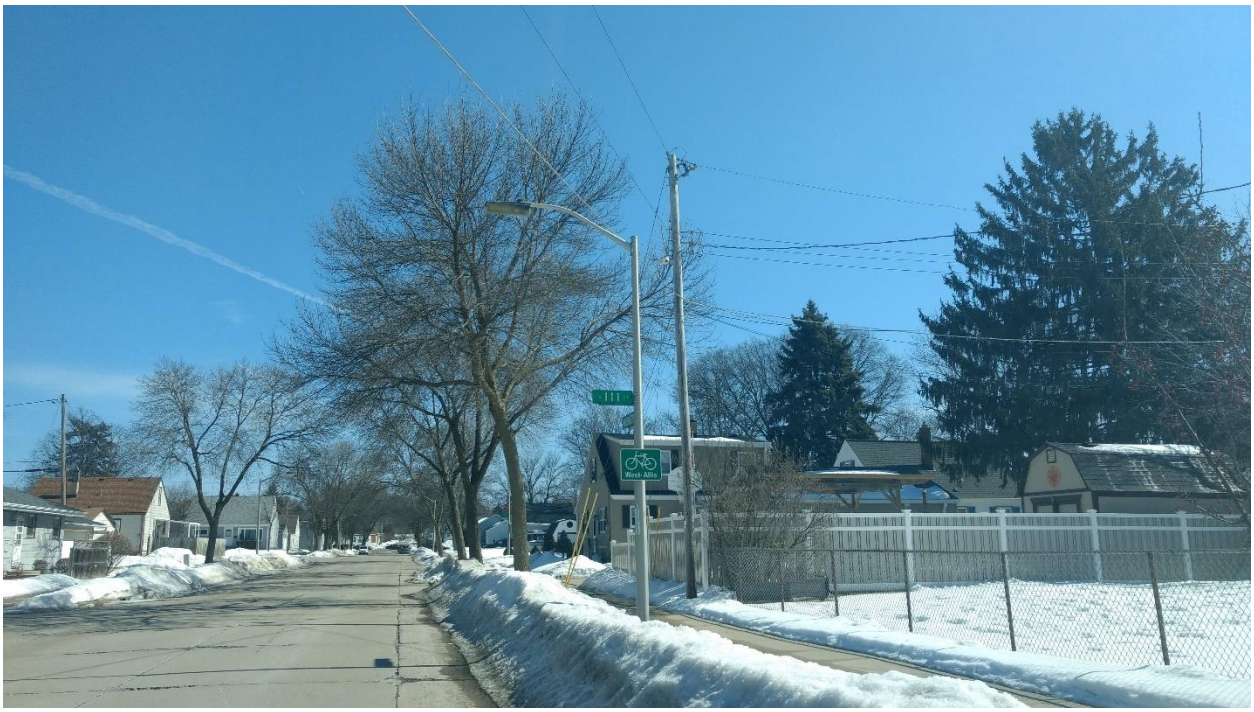
West Allis Street Lighting

Planning Study for LED Conversion and Series Circuiting Upgrades

OCTOBER 10, 2019



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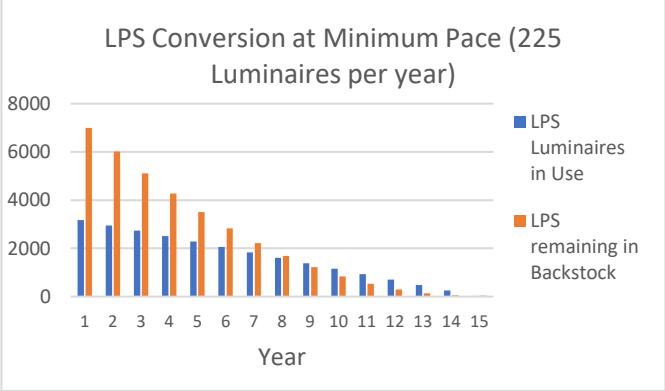
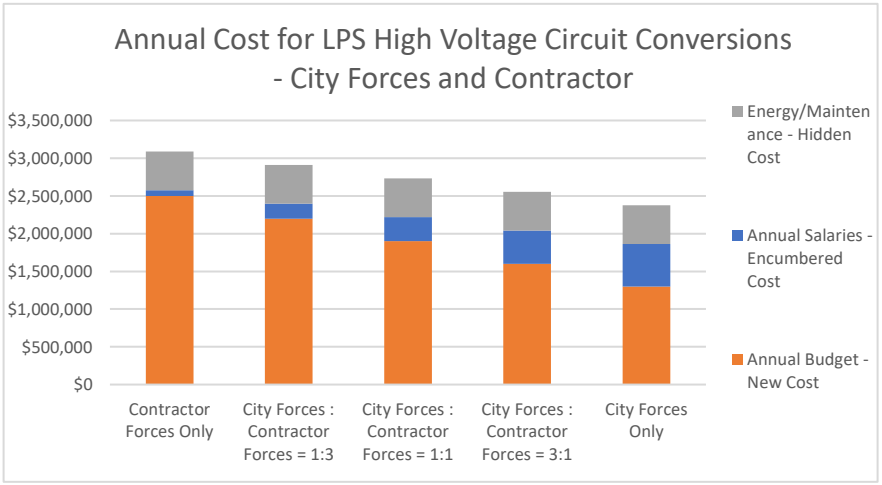
Executive Summary

The City of West Allis Department of Public Works Electrical Services Division is responsible for maintaining and operating the City's entire lighting system, comprised of 51 low-voltage parallel circuits and 77 high-voltage series circuits. High-voltage series circuits can serve larger areas than their counterpart, however it can be extremely dangerous to perform routine maintenance on systems with such high voltages, therefore specialized training is required for all City electrical staff. Additionally, high-voltage series systems are much more costly and time-consuming to repair and maintain, and the required infrastructure is rapidly becoming obsolete. With the recent discontinuance of low-pressure sodium (LPS) luminaire manufacturing, the City has approximately 7 years before large numbers of streetlight fixtures begin to go dark. This planning study is intended to evaluate alternatives for upgrading the City's lighting system to ensure lighting systems remain operational, to increase overall efficiency and to take advantage of cost-savings resulting from decreased energy usage and maintenance.



Upon completion of this study, it has been concluded that 225 LPS luminaires must be converted from high-voltage series circuitry, to low-voltage parallel circuitry annually to maintain continuous lighting in all areas. The most economical method to accomplish this is to maximize the amount of circuit conversions completed by City forces, and to supplement that amount with locally let projects to a contractor in order to maintain the minimum pace of 225 LPS luminaires per year. The ratio of City to contractor circuit conversions can be adjusted annually to match work force capabilities.

KL Engineering recommends that the City of West Allis prepare to budget between $1.5M and $2M annually for the next 13 years in an effort for convert all high-voltage series circuits with LPS luminaires in operation. Upon conversion of these circuits in 13 years, priority will shift towards the remaining high-voltage series circuits with HPS luminaires, which are estimated for completion in an additional 6 years at the current pace (19 years total).



Introduction

The City of West Allis has completed a planning study to evaluate alternatives for long term upgrades to the lighting systems on streets throughout the City. The Department of Public Works (DPW) Electrical Services Division is responsible for constructing, maintaining and operating the City's lighting system. This system not only includes individual streetlights, but also circuitry, electrical substations (node facilities that provide electricity to the circuits), control systems, and other components. As of 2019, West Allis' streetlight infrastructure was made up of 128 circuits, approximately 23 percent (51 circuits) of which were low-voltage parallel circuits and approximately 77 percent (77 circuits) of which were high-voltage series circuits. Those high-voltage series circuits are comprised of approximately 3,179 low pressure sodium, 2,701 high-pressure sodium and 94 metal halide luminaires.

The City of West Allis began installing most of the current high-voltage series circuits in 1935 when this type of circuitry was preferred for compatibility with incandescent street lighting. However, incandescent lighting became obsolete for streetlighting decades ago, and starting in the 1990's the City began the process of transitioning their streetlight infrastructure from series circuitry to more modern parallel circuitry. The different characteristics of series circuitry and parallel circuitry impact how West Allis' street lighting system functions.

Compared with parallel circuits, series circuits can serve larger areas and accommodate more lights per circuit. When series circuits fail, however, larger areas of the City will be affected. After a street lighting outage is reported to the DPW, the circuit experiencing the outage is usually repaired within 24 hours in order to restore operations. Series circuits, however, are costly and time consuming to repair compared with parallel circuits. The City of West Allis anticipates that by replacing series circuitry with parallel circuitry, operating efficiency will increase, and maintenance costs will be reduced.

Part of this overall maintenance cost difference is attributed to the cost of series circuit components, being that The City of West Allis is one of a few remaining users of the type of specialized wire needed for its series circuits. In addition, the series circuits also require customized ballasts for making connections to the lighting fixtures to make them compatible with high-voltage circuiting. Another significant component of the maintenance cost difference is the amount of time required for repairs. Since the expertise needed for working on series circuits is highly unique and largely obsolete, the City must significantly invest in training staff electricians before they have the knowledge required to safely work on high-voltage series circuits. This specialized training requires considerable time and City resources.

These issues—materials, time, and labor costs—have been preventing the City of West Allis from addressing outages as efficiently as possible. Accelerating the process of upgrading from series to parallel circuits could reduce the expenses involved in making repairs. Moreover, there are fewer outages on parallel circuits than on series circuits, which suggests that by making the upgrade, DPW staff may have fewer overall outages to address. Additionally, the upgrade to parallel circuits will mean that it will take less time to repair outages, which may create additional benefits to the City and residents of West Allis by making the City's street lighting more reliable.

Another issue the City of West Allis is facing is the recent manufacturing discontinuance of low-pressure sodium luminaires and the pending manufacturing discontinuance of high-pressure sodium luminaires as well. The City currently has over 3,100 low-pressure sodium luminaires attached to high-voltage series circuits in operation. The City recently purchased 7,000 low-pressure sodium replacement bulbs in order to stockpile resources, however, this backstock will be depleted in approximately 7 years, at which point the City will start to lose street lighting without the ability for routine maintenance.

The City of West Allis is investigating the efficiency and costs-savings of accelerating the streetlight upgrade project so that most or all circuit upgrades are completed within a shorter time period to ensure the City's street lighting does not go dark. The study evaluated upgrading the remaining circuits using several alternative upgrade schedules and methods, and measured the costs and benefits that would accrue to the City of West Allis under each option.

Data Collection

The City of West Allis maintains a comprehensive GIS database that tracks all street lighting by circuit type (high vs. low-voltage) and luminaire type. This information was made available for the study and was utilized to determine the baseline conditions for the City's streetlighting system.

Energy Consumption

Total energy consumption is typically the most common metric for the analysis of streetlighting conversions to LED. Streetlights are assumed to operate for approximately 4,160 hours per year, which is based on the average length (seasonally) of daylight conditions for the State of Wisconsin. Using total wattage for all luminaires on system, the City of West Allis is estimated to consume approximately 2.5 million kWh of energy annually. All LPS and HPS luminaires also have an associated amount of wasted energy, which is estimated at 25% of the respective luminaire wattage, and accounts for inefficiencies in the luminaires ballast, heat loss and start-up loss. Applying a typical cost per kWh of 12.5 cents, total energy cost for the entire street lighting system is calculated to be $376K annually.

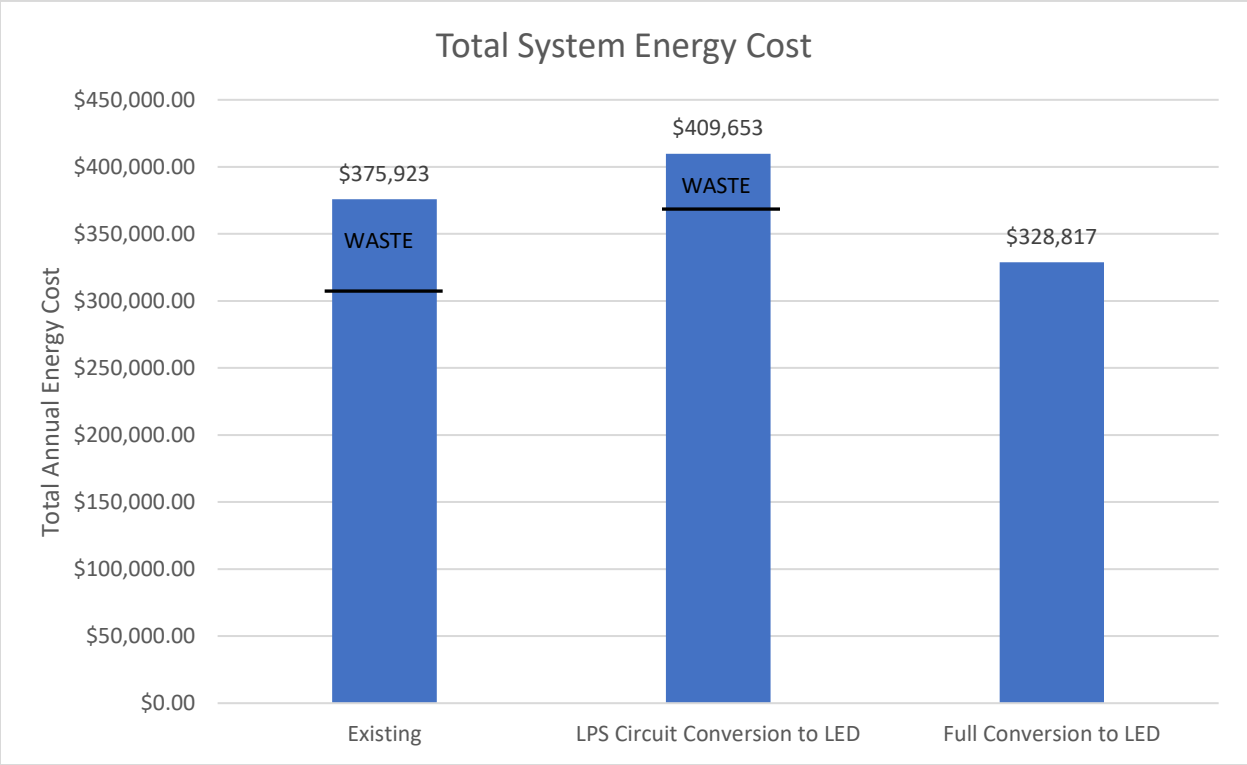


Figure 1 Total System Energy Cost

The graphic above depicts the estimated City of West Allis annual cost of energy under current operations. For comparison, the energy cost once all circuits containing LPS luminaires have been converted is shown, as well as the final cost once all systems are low-voltage parallel circuits with LED lighting. This graphic does not include the metric of time required for conversions; therefore, inflation has not been applied to this data.

Due to the relatively low operating wattage of low-pressure sodium luminaires, converting these to LED will result in added energy expenses. However, the City also uses many high-pressure sodium luminaires on both high and low-voltage circuits, which require a much larger operating wattage and will result larger energy savings upon retrofit to LED. The energy increase from an LPS retrofit, and the reduction from an HPS retrofit will eventually result in overall energy savings.

Although direct energy savings from a total LED retrofit may not be as large as some communities that entirely replace HPS luminaires, the energy efficiency in terms of lumens per watt (i.e. less wasted energy) will be greatly improved. Overall the quality of lighting will be greatly enhanced with LED technology given

they output more light for less energy expended. Due to this increased efficiency, the City of West Allis is eligible for rebate incentives from Focus on Energy that will result in additional savings.

Maintenance

Total cost of streetlighting maintenance is another significant metric evaluated with this study. The City currently requires 4 electricians full-time to perform streetlight maintenance. A large portion of this maintenance is due to the high-voltage series circuits, which require frequent troubleshooting to identify needed repairs. For example, the City reported that it currently has 15 circuits that are interrupted due to ground faults, but due to the high-voltage circuitry, it is very difficult to isolate the problem and make repairs. In addition to the commitment to maintaining high-voltage circuiting, City electricians are responding to knockdowns at an estimated rate of 1.6 per week, as well as other periodic outages that get reported or observed.

The amount of high-voltage system maintenance will be reduced as circuits are converted, which will translate to an increasing amount of savings generated from the lighting conversion over time. It will take City forces less time to locate and repair malfunctions if the ballasts are no longer underground and faults become less frequent. This reduction of maintenance may result in a growing capacity for City staff to perform more conversions in the same amount of time, potentially saving money on future conversion projects. Replacement material costs will also decrease as obsolete circuitry is removed and replaced with modern components. And finally, the scaled back amount of training and expertise required for these specialized electrical systems will create long term savings upon hiring and recruiting new staff.

Theoretically, the maintenance of high-voltage systems can be isolated and quantified. This study estimated that the City of West Allis currently spends approximately $194K annually on high-voltage circuit maintenance. This value is based on the salaries of 4 City of West Allis electricians spending approximately 45% of their time maintaining high-voltage circuits and their respective luminaires, and is in addition to the cost of training staff to work with these high-voltage systems. Using publicly available data for streetlighting maintenance contracts in Milwaukee County, and pro-rating the numbers to remove typical contractor mark-ups, it is estimated that a low-voltage HPS luminaire costs $21.26 annually. Given that LED luminaires are estimated to last at least 4 times longer than HPS, it is estimated that a low-voltage LED luminaire will cost $5.32 annually. Back-calculating based on the inventory of West Allis streetlights, it can be determined that each high-voltage LPS or HPS luminaire costs $37.44 annually to maintain.

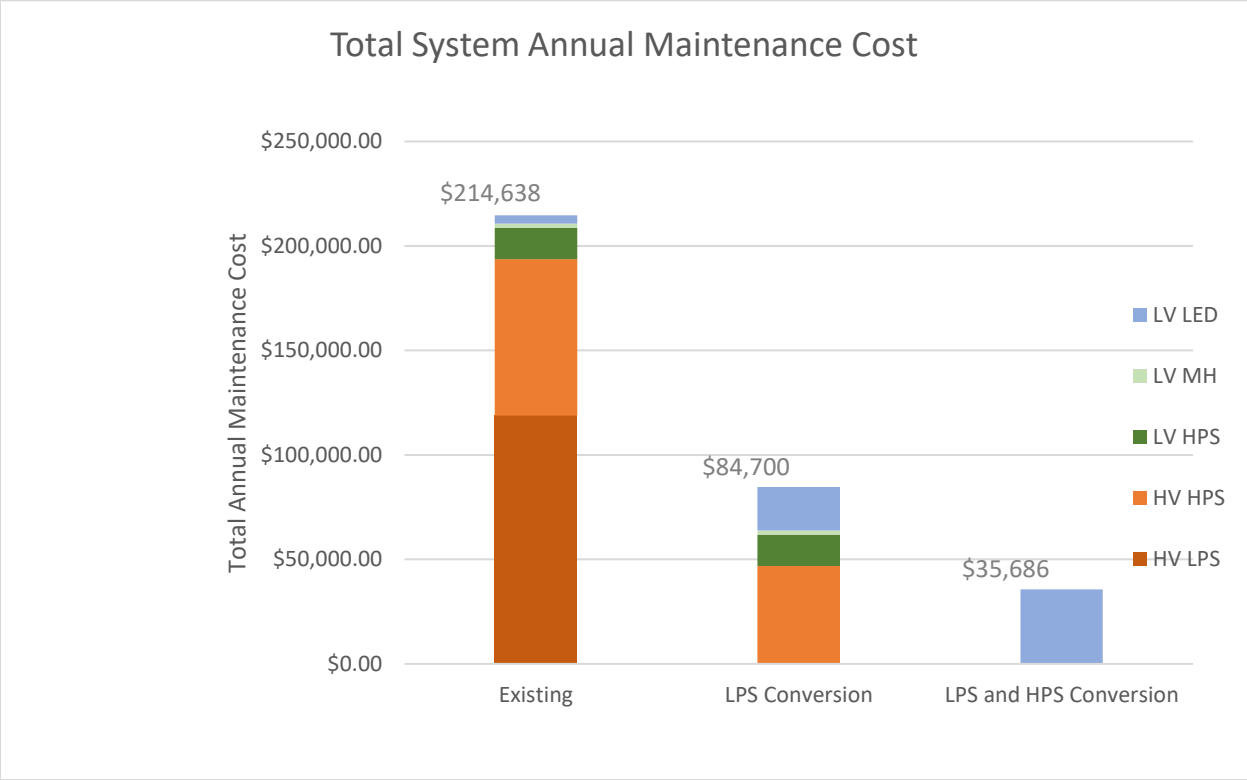


Figure 2 Total System Maintenance Cost

The graphic above depicts the estimated City of West Allis annual cost of maintenance under current operations, and with future conversion to low-voltage and LED. For comparison, the maintenance cost once all circuits containing LPS luminaires have been converted is shown, as well as the final cost once all systems are low-voltage parallel circuits with LED lighting. This graphic does not include the metric of time required for conversions; therefore, inflation has not been applied to this data.

From the standpoint of a City of West Allis taxpayer, these annual costs would be distributed across the 29,353 housing units that make up the City of West Allis (according to the 2010 census). Applying the above data across all households, an estimated average taxpayer cost can be obtained. All previous assumptions remain applicable.

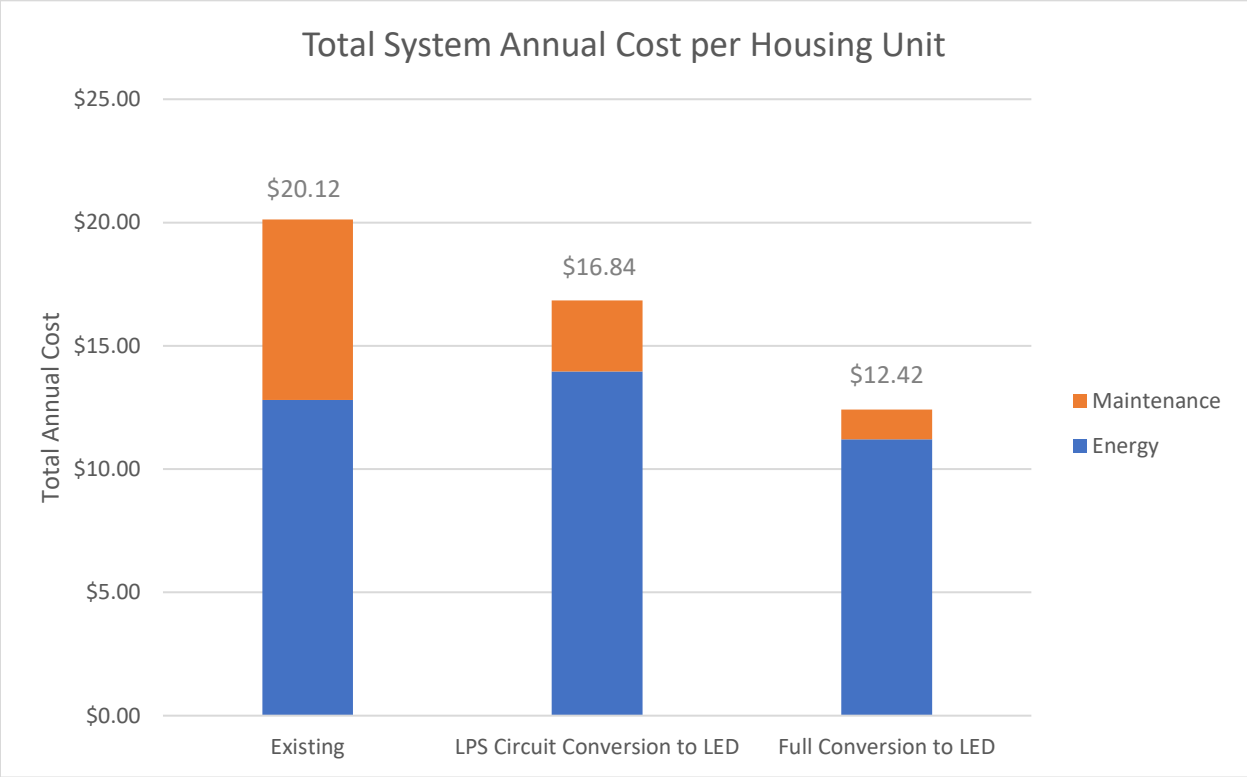


Figure 3 Total System Annual Cost per Housing Unit

Rebate Opportunities

Multiple rebate opportunities were explored in relation to high-voltage series circuit conversion, and LED conversion. Focus on Energy was identified as the only organization that provides incentives directly applicable to the City of West Allis streetlighting conversions. Focus on Energy is a State of Wisconsin based program that provides rebate opportunities for energy savings measures made by governmental agencies, commercial properties, and residents alike.

If the City of West Allis were to have their electrical staff perform LED lamp replacements with a voltage transformation kit, the City would be eligible for a small mogul screw base rebate. This rebate is based on wattages, where the agency will receive $0.15 per watt replaced. The problem with this option is that the City is going to be replacing low-pressure sodium bulbs, which operate at a lower wattage than their LED counterpart. Therefore, there is no rebate incentive available for retrofitting LPS luminaires with individual transformation kits.

If the City of West Allis decides to perform full circuit conversions from high-voltage series to low-voltage parallel, the City would be eligible for LED luminaire rebates. Unlike the mogul screw base rebates, the

LED luminaire rebate is based on lumen output of the proposed LED luminaire. The table below shows the different incentives for ranges of lumen output replacements.

Output	Luminosity Range	Incentive
Low	<4,999	$20
Mid	5,000-9,999	$35
High	10,000-29,000	$50
Very High	>30,000	$120

Table 1 LED Specification Performance Criteria

Based on the incentive values above and the City's luminaire inventory, it is estimated that the City has approximately $222K in potential Focus on Energy rebates. Furthermore, for long term conversion plans, such as the situation West Allis faces, incentives can be locked in for extended periods of time to ensure that changes or reductions in the rebate program do not impact rebate expectations. Initial contact has been made with Focus on Energy representative, Tom Dragotta.

Low-Pressure Sodium Luminaires

The City of West Allis currently has approximately, 3,179 low-pressure sodium luminaires in operation. Upon notification that these bulbs will no longer be manufactured or commercially available, the City made an emergency purchase of 7,000 bulbs. A standard low-pressure sodium bulb will begin to degrade and add stress to the circuit 3 years after its installation, at which point it must be replaced. Therefore, under current operations and with the newly acquired backstock, the City of West Allis has only 7 years before those lights begin to go out and become irreplaceable.

To avoid this eventual loss of light and prevent the streets of West Allis from going dark, these low-pressure sodium bulbs must be replaced by either retrofitting individual luminaires to LED using individual transformers, or by converting entire circuits to low-voltage. The figure below describes the minimum rate at which LPS luminaires must be replaced to ensure the recently purchased stockpile will suffice.

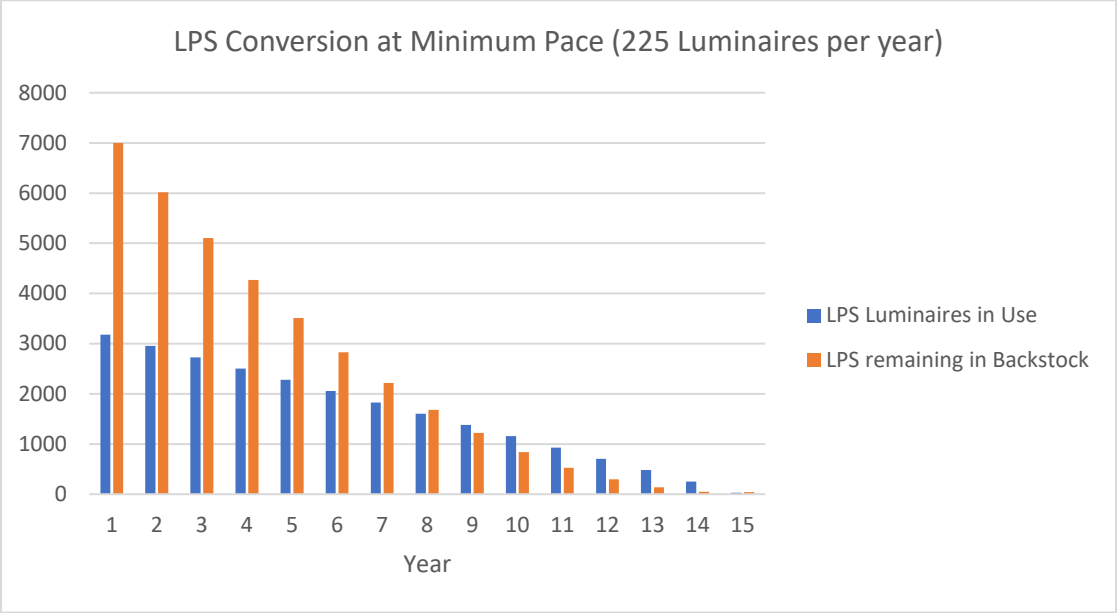


Figure 4 LPS Conversion at Minimum Pace

By replacing at least 225 low pressure sodium luminaires per year, the City can expect to have all LPS bulbs removed from operations in 13 years. These numbers do not account for potential breakages or premature failures of bulbs, so the overall goal should be to replace 225 bulbs per year at a minimum. Replacing significantly more bulbs than 225 per year will result in complete LPS removal in a shorter time span, however backstock will not be depleted so the City will be forced dispose of the remaining bulbs and essentially lose the money spent.

High-Voltage Data Extrapolation for LPS Circuits

All high-voltage lighting circuits in the City of West Allis are comprised of varying quantities of luminaires and various luminaire types, making each circuit unique across all measurable variables. In order to utilize statistical data for this study and create a comparison of circuit conversion alternatives, standardized circuits were created.

All high-voltage circuits that have low-pressure sodium luminaires in operation were combined and averaged, 50 circuits total. The resulting circuit is considered the standard high-voltage low pressure sodium circuit (HV LPS). A Breakdown of the components that make up the standard HV LPS circuit are shown in the following table

Luminaire Type	HPS						LPS		MH	
Luminaire Wattage	50	70	100	150	200	250	35	55	250	70
Total Circuits with LPS luminaires	50									
Average Luminaires per Circuit	79									
% per Circuit	0%	4%	3%	12%	1%	0%	29%	52%	0%	0%
# per average LPS HV circuit	0	3	2	9	1	0	23	41	0	0

Table 2 Average LPS Circuit

The remaining high-voltage circuits that exist in the City of West Allis, 27 circuits total, are considered high-voltage high-pressure sodium circuits (HV HPS). A breakdown of the components that make up the standard HV HPS circuit are shown below.

Luminaire Type	HPS						LPS		MH	
Luminaire Wattage	50	70	100	150	200	250	35	55	250	70
Total Circuits Remaining	27									
Average Luminaires per Circuit	48									
% per Circuit	0%	5%	7%	66%	21%	1%	0%	0%	0%	0%
# per average LPS HV circuit	0	2	4	32	10	0	0	0	0	0

Table 3 Average HPS Circuit

These two types of standard circuits will be referenced and used as methods for comparison for the remainder of this study. These numbers are to be used as approximations for budget estimates only. Exact numbers will need to be determined on a case by case basis once a conversion plan is implemented.

Construction Estimates and Methodology

City Work Force and Equipment

The City of West Allis currently employs 11 total staff members dedicated to operations and maintenance of City Electrical systems such as traffic signals, street lighting, facilities, and other electrical infrastructure. Their primary duties include routine maintenance, emergency repairs and supporting Capital Improvement Projects (CIP) projects. In addition to the electrical staff, the City purchased a boring rig in early 2019, and has a hydro vac truck that is shared with other departments.

Throughout 2019, the City's electrical staff has been working on the conversion process of circuits F-1 and A-3. Due to the electrical staff's commitment to these projects, standard operations tasks have been neglected and are not being addressed. Additionally, routine maintenance and other daily activities are frequently disrupting the staff's commitment to the circuit conversion projects, thus hindering ideal production rates to complete the conversions.

The study concluded that existing City electrical staff will not have capacity for keeping pace with the current amount of circuit conversions, let alone with replacing enough circuits to meet the minimum required conversion of 225 LPS luminaires per year. It is estimated that the City will need to hire an additional 6-8 employees, all strictly dedicated to circuit conversion, in order to keep up the minimum pace of LPS luminaire replacement. The City also may be faced with the purchases of an additional boring rig, and hydro-vac truck(s) to maintain efficiency with multiple crews.

Filling 6-8 electrical positions is anticipated to be a significant challenge for the City. The City has had open positions on their electrical staff for an extended period and are having issues filling them. This can be attributed to a competitive job market in the electrical industry that makes hiring and retaining electrical staff a difficult task. Additionally, the specialized requirements of working with high-voltage series circuit lighting mean most new hires will not have adequate experience and must be extensively trained before they can begin work.

Construction Methodology

This study narrowed down construction methodologies to three (3) options for making high-voltage lighting conversions: construction by City forces, construction by contractor with local let projects, or construction by WE Energies sub-contracted forces. In all instances, production rates must maintain a minimum conversion of 225 LPS luminaires per year, otherwise risking depletion of luminaire backstock and incurring the wasted cost of retrofitting individual luminaires with transformers. Being that all circuits are different, the total amount of construction will vary from year to year based on total number of LPS luminaires per circuit.

Keeping construction in-house by utilizing City forces will allow the City to procure all items and ensure that nothing is outsourced. This option will also provide for the most flexibility when deciding when and what circuits to convert, allowing circuit conversions to easily be coupled with roadway improvement projects. Actual capacity for conversion projects by City forces is completely dependent on ability for City to hire and maintain adequate staff levels. While this alternative appears to be highly desired due to cost, hiring and staffing may diminish the practicality of keeping all work internal to City forces.

Construction by contractor forces, or WE Energies contracted forces, assumes that everything will be outsourced for the purpose of this study, although there may be potential for City procurement with contractor installation. These alternatives remove the concern for the City's ability to hire and maintain adequate staffing, while providing more flexibility on the speed and production rate of circuit conversions.

The major concern with these options is the unique requirements of high-voltage series circuity, which in the past has limited the amount of contractor bids and eliminated the competition for work, thus inflating bid prices.

A WE Energies contract means that the energy provider will assume long-term ownership of all circuits that they convert. As circuits transition to WE Energies ownership, the City will no longer be responsible for maintaining those systems, thus reducing the workload of existing City electrical staff. Although the City will no longer have the associated maintenance and energy operations costs associated with those circuits, WE Energies will charge a monthly fee that will outweigh those costs (see table below). Additionally, by putting WE Energies in charge of contracting the work, a competitive bidding market will be eliminated, and construction costs will be under the control of the utility company.

WE Energies Equivalent						
	Oval			Rectangular		
Monthly Charge	$7.77	$10.33	$13.20	$8.74	$11.30	$14.17
Luminaire Type	Low 4K	Med 4K	High 4K	Low 3K	Med 3K	High 4K
Wattage	48	97	157	59	104	165

Table 4 WE Energies Operations Fees

Construction Cost Estimates

Construction costs of the three methodologies described above were estimated as part of this study. For simplicity, all costs were converted to an approximate unit of cost/luminaire, and then extrapolated over the standard circuits as described previously. These costs can be used to estimate a standard annual budget, with the understanding that actual budget will vary slightly based on which specific circuits are being converted.

The construction cost for City forces performing work was provided by the City of West Allis based on the recent conversion of the F-1 circuit. The estimate included maintenance costs for the newly acquired boring rig, as well as all other materials necessary to complete construction. The estimate assumes that the City will be able to re-use a majority of the existing concrete bases, as well as a majority of the street lighting components (poles, bases, arms etc.). The estimate provided was indicated as being for parts and materials only, labor was stated as being included elsewhere.

Construction costs for locally let projects to contractors were also provided by the City, based on the recent conversion of the F-1 circuit. The actual construction came in higher than anticipated, so the City decided

to perform the work with their own forces. These bid prices were verified by creating engineers estimate of circuit D-5, which represented a standard high-voltage circuit with minimal variation in infrastructure. This estimate assumed that aluminum poles and arms are 75% re-usable, while concrete and steel are not re-usable. Furthermore, this estimate added a 10% cost for miscellaneous contingency and engineering. Total construction bid prices were found to be similar to those provided for the F-1 circuit

Construction costs for a WE Energies contract were very similar to that of a contracted project; however, it is assumed that nothing would be re-usable and WE Energies would require all new infrastructure that meets utility standards. The contingency for a WE Energies contract was increased to 20%, which accounts for their own internal mark-ups as they procure all items. This estimate also assumed a higher cost for engineering, as they will be designing these systems separately.

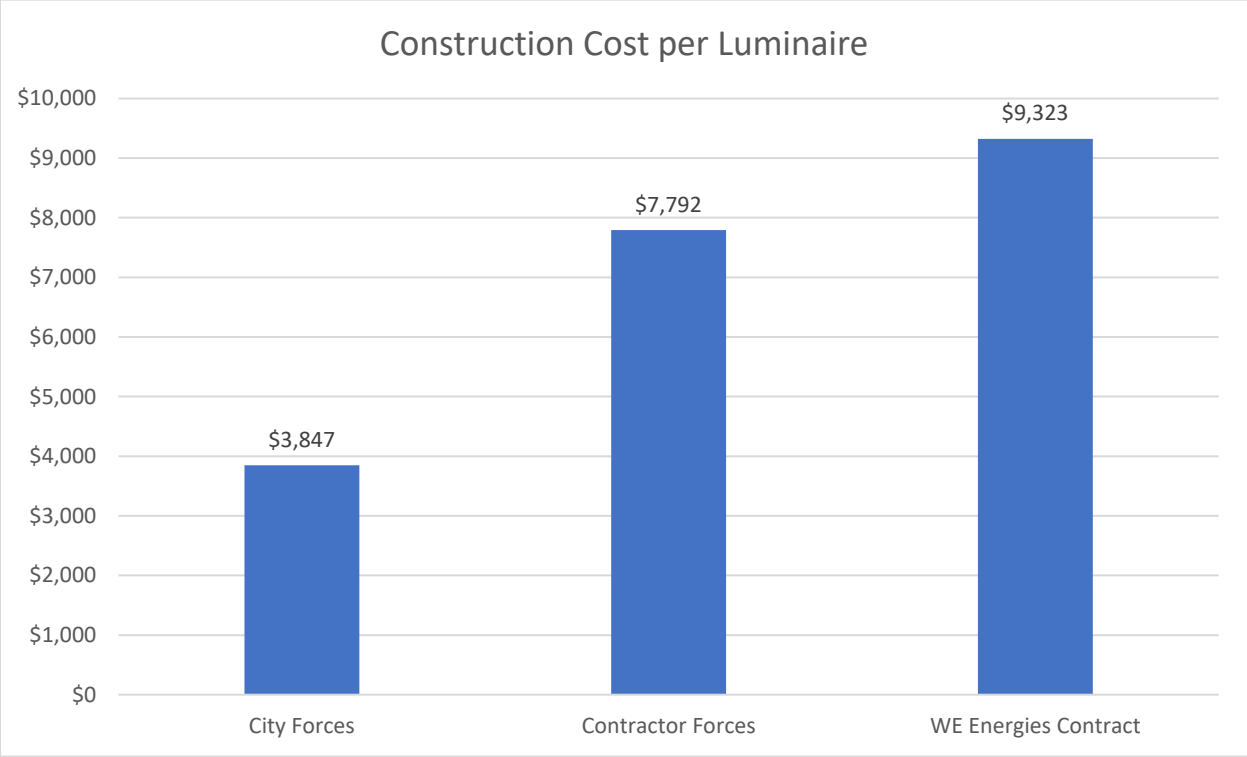


Figure 5 Construction Cost per Luminaire

Labor Cost Estimates

Labor costs of the three methodologies described above were estimated as part of this study. For simplicity, all costs were converted to an approximate unit of cost/luminaire, and then extrapolated over the standard circuits as described previously. These costs can be used to estimate a standard annual City labor budget, with the understanding that actual budget will vary slightly based on specific circuits being converted.

The labor cost for City forces completing construction projects assumes that the City can hire and maintain an adequate work force. The estimate assumes that 4 new electrical staff employees, strictly dedicated to circuit conversions, can complete up to 3 standard circuit conversions per year. This estimate assumes a typical electrical employee earns an hourly wage of $57.26, which was provided by the City and includes bonuses and holiday time

Having a contractor, or WE Energies, complete the work will incur labor costs from both City and contractor forces. The City will need to provide a staff member to provide construction oversight, while the contractor will have their own labor costs which are included in bid pricing. City forces labor was estimated based on a contractor completing a standard circuit conversion in 2 months, with a City employee providing oversight for the entire time. Contractor labor was estimated using the ratio of City labor cost to City construction cost, and applying it to the estimates previously obtained for contractor and WE Energies construction costs.

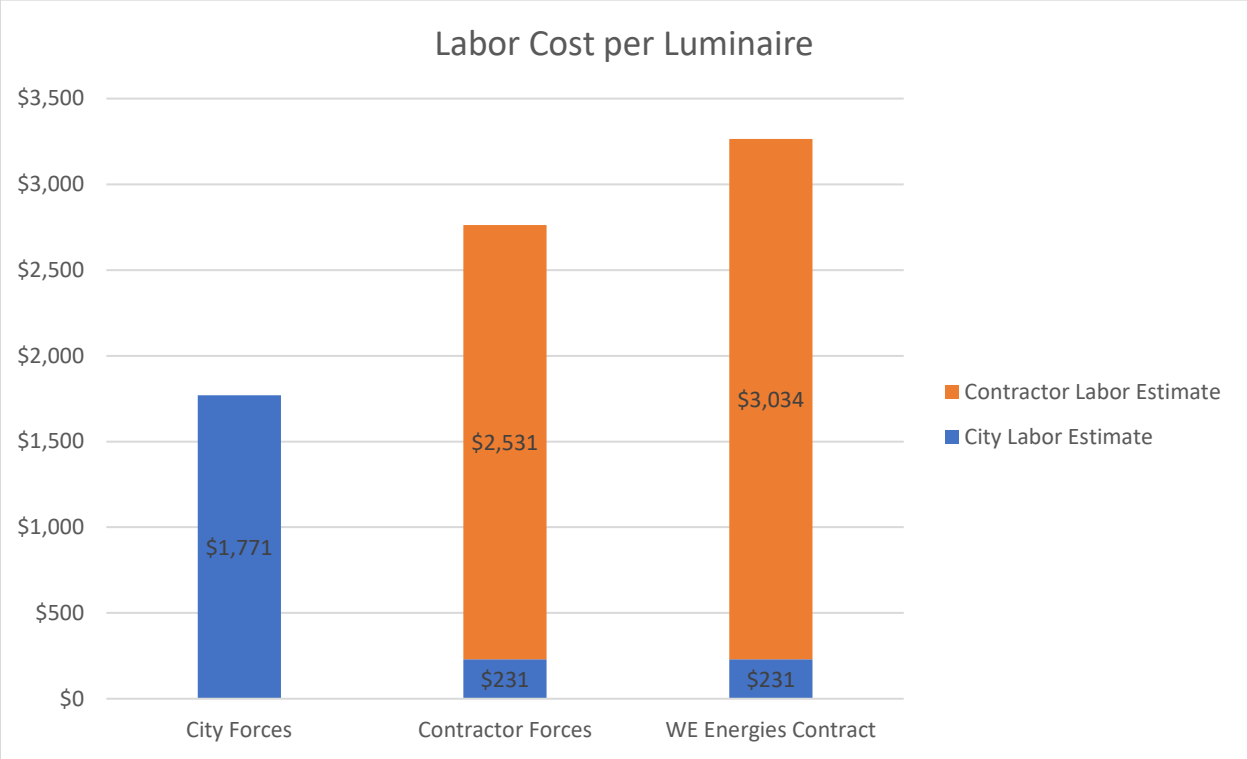


Figure 6 Labor Cost per Luminaire

Comparison of Alternatives

High-Voltage Low-Pressure Sodium Circuits

The highest priority for circuit conversions, as previously described in data extrapolation, include all high-voltage circuits that contain LPS luminaires. The annual net cost of performing these circuit conversions using the three construction method alternatives is shown in the graphic below. The construction cost for Contractor and WE Energies forces includes the external work force labor component.

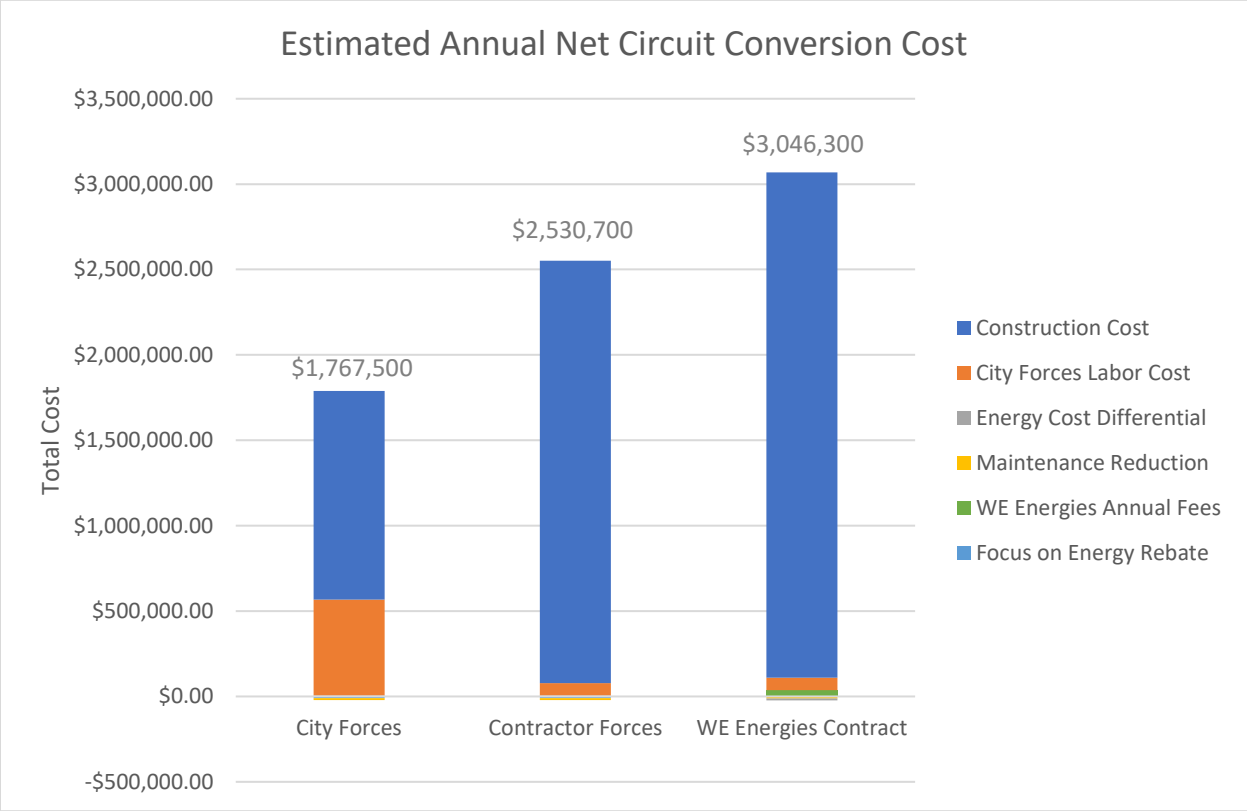


Figure 7 Estimated Annual Net Circuit Conversion Cost LPS

High-Voltage High-Pressure Sodium Circuits

The remaining circuit conversions, as previously described in data extrapolation, include all high-voltage circuits that contain HPS luminaires. The annual net cost of performing these circuit conversions using the three construction method alternatives is shown in the graphic below. The construction cost for Contractor and WE Energies forces includes the external work force labor component.

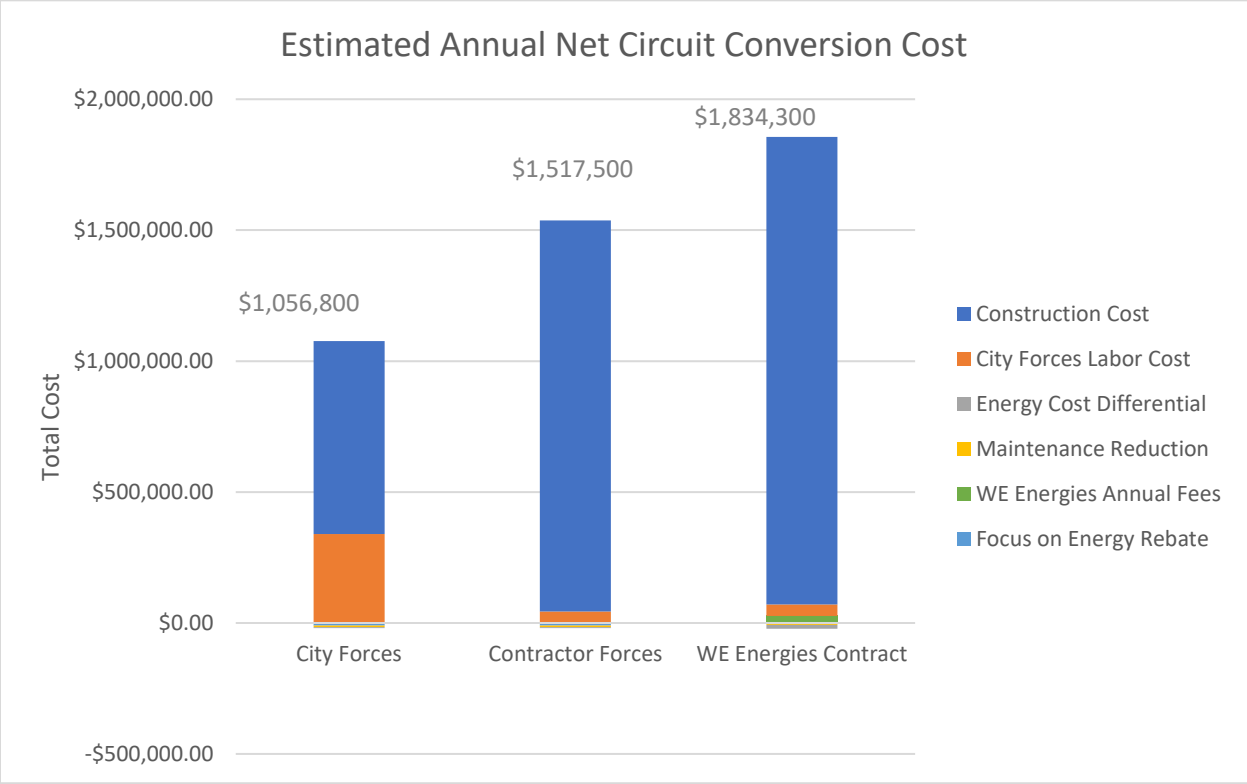


Figure 8 Estimated Annual Net Circuit Conversion Cost HPS

Full System Conversion

Performing all circuit conversions at the minimum pace of 225 LPS luminaires per year, or approximately 4 standard circuits per year, results in all HV LPS circuits being fully converted in 13 years. The remaining HV HPS circuits will take another 6 years, resulting in a completion time for the entire street lighting system conversion of approximately 19 years. Applying an annual inflation rate of 1.5%, we are able to estimate a final compounded construction cost for all three methodologies.

Alternative	Years Until Priority 1 Completion	Years Until Total Completion	Annual Construction Budget (Initial) - New Money	Total Construction Budget - New Money
City Forces Perform All Work	13	19	$1,300,000	$22,800,000
Contractor Forces Perform All Work	13	19	$2,500,000	$46,300,000
We Energies Contract	13	19	$3,000,000	$55,600,000

Table 5 Construction Costs for Full Conversion

By combining labor and operations cost, as well as rebate incentives, this study was able to determine final compounded costs to the City of West Allis for the entire streetlight conversion plan. The energy and maintenance metric, as well as the WE Energies fee's will all continue beyond the lifespan of this master plan, at annual rates previously described.

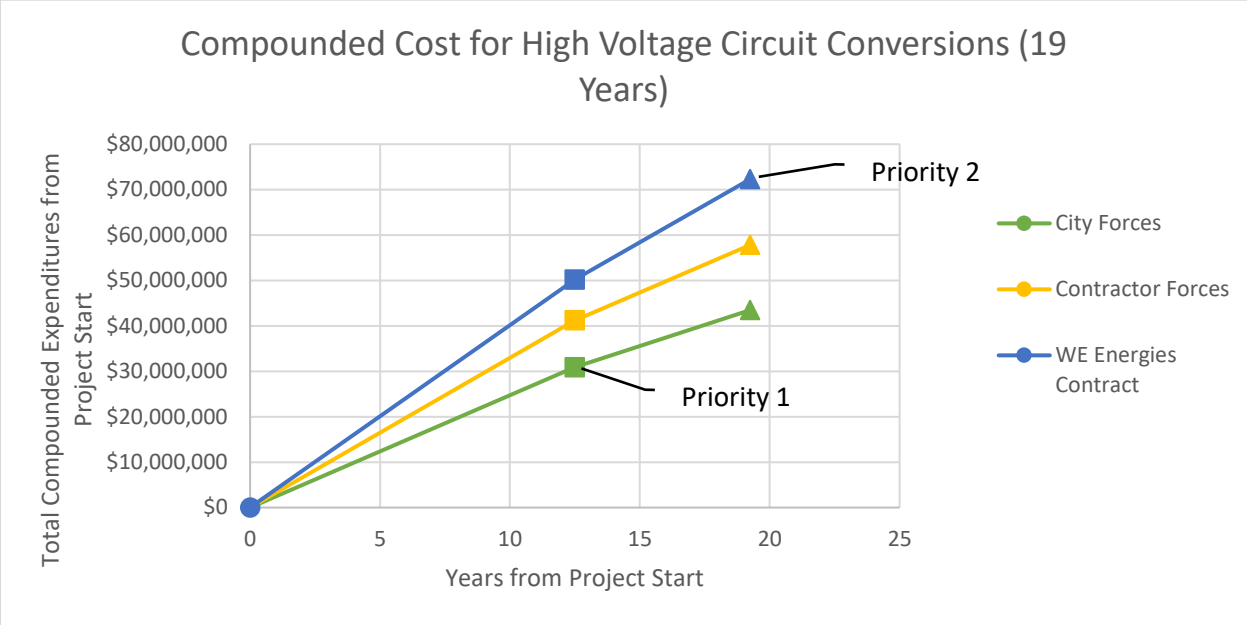


Figure 9 Compounded Cost for High-voltage Circuit Conversion

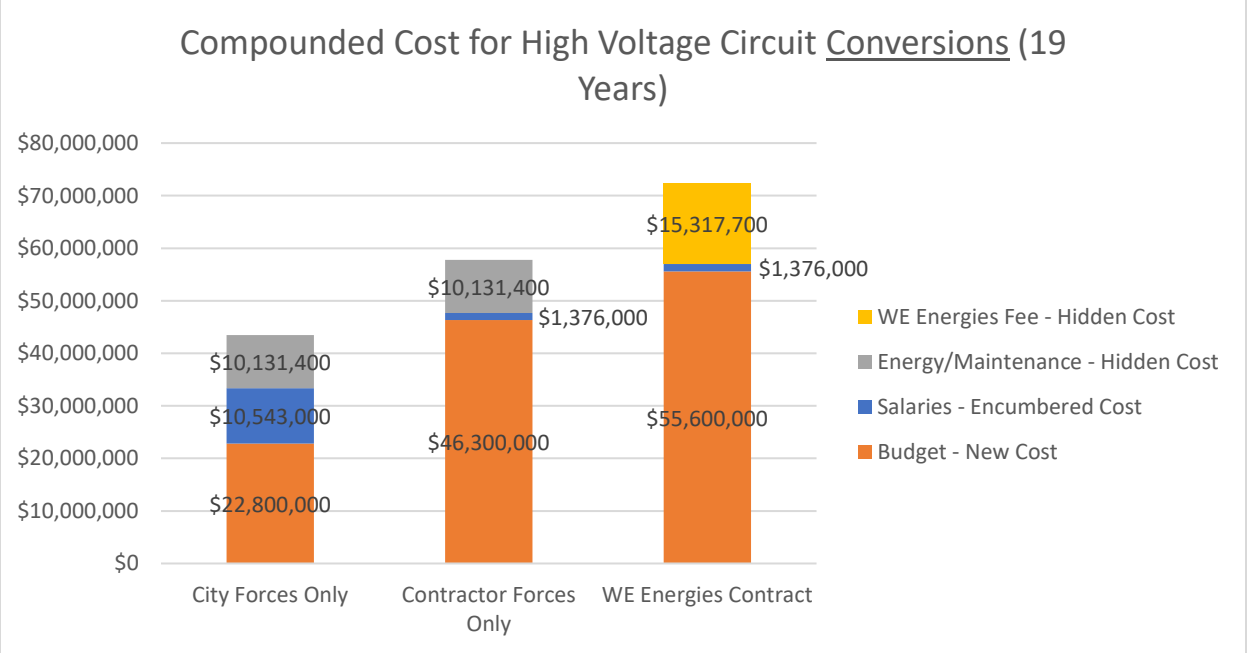


Figure 10 Compounded Cost for High-voltage Circuit Conversion

Recommendations and Conclusions

General Conclusions

Upon completion of this study, it has been concluded that 225 LPS luminaires must be converted from high-voltage series circuitry, to low-voltage parallel circuitry annually to maintain continuous lighting in all areas. Failure to meet this minimum pace will eventually result in blackouts across the City or will force the City waste budget on individual luminaire retrofits. In order to accomplish this, all circuits with LPS luminaires in operation must be targeted as highest priority. Any additional conversions that can be afforded will only aid the process and relieve stress from the LPS backstock.

A contract or partnership with WE Energies can be ruled out due to excessive costs and unknowns. The monthly rate at which WE Energies will charge the City for ownership will greatly outweigh the operational costs of energy and maintenance being replaced.

City forces are by far the most cost-effective construction alternative, however there are multiple factors that must be considered before this option can be implemented. Challenges with hiring and maintaining City electrical staff must be secured before this alternative can be considered practical. The staff must be trained and be capable of maintaining a high rate of progress to be tasked with circuit conversions at the pace required. In the event that City staff cannot be acquired and/or retained, contractor forces are considered the next viable alternative, but with a higher capital cost to the City.

This study concludes that the most practical scenario, which is based on cost savings and production capabilities, is to maximize the amount of circuit conversions performed by City work forces, and to supplement that amount with locally let projects to a contractor in order to maintain the minimum pace of 225 LPS luminaires per year. Circuit conversion by contractors can be coupled with roadway reconstruction projects, so that only one project must be let and the effort to oversee the bidding and contracting process is minimized. Additionally, the ratio of City to contractor circuit conversions can be adjusted annually to match work force capabilities. As City forces become more familiar with completing the work and production rates increase, this ratio will likely shift to solely City forces performing circuit conversions. The following graphic depicts estimated annual costs for likely ratios of City to contractor construction.

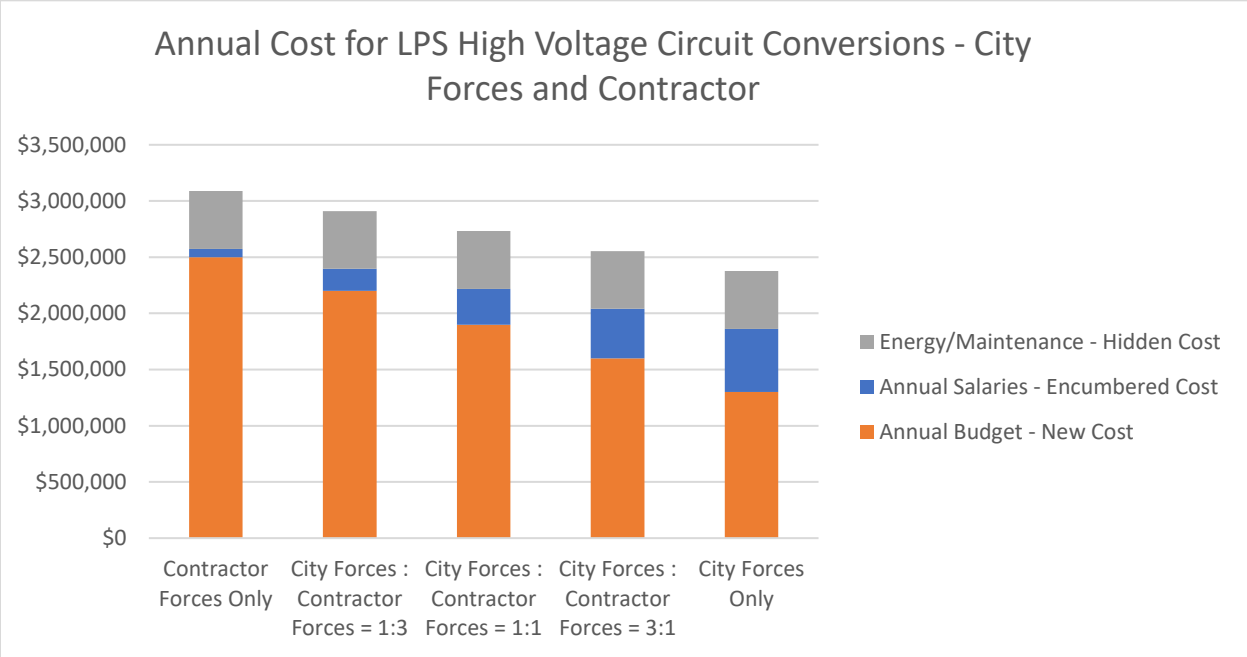


Figure 11 Annual cost for LPS High-Voltage Circuit Conversion

Applying an interest rate of 1.5%, and compounding the cost of operations, construction and labor over the lifespan of the circuit conversion plan, a final compounded cost for high-voltage circuit conversions can be determined as shown below.

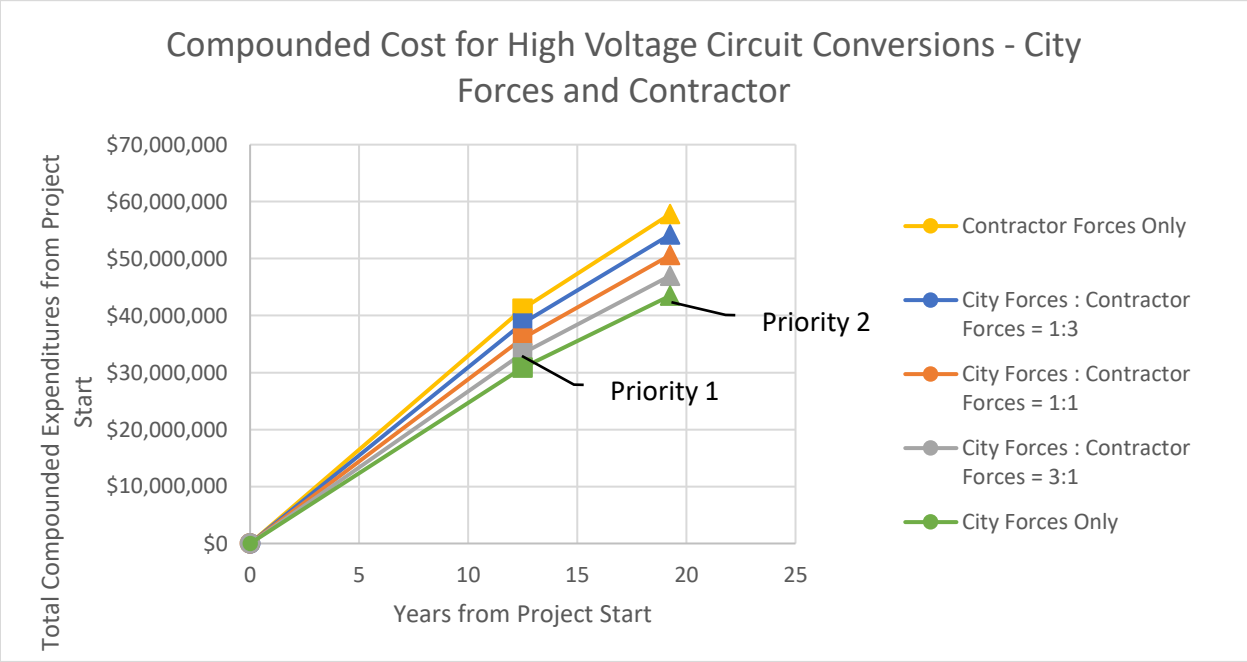


Figure 12 Compounded Cost for High-Voltage Circuit Conversion

A Lighting project Analyzer spreadsheet was developed as part of this study, which allows the City of West Allis to analyze infinite scenarios for order of specific circuit conversions, and methods of construction. This analyzer will allow the City to optimize this master plan in order to ensure the City does not go dark, while implementing the most cost-effective plan. A preliminary plan for the high priority circuits is shown in the graphic below, which assumes that City forces can perform all circuit conversion construction. The orange line represents the average annual construction cost of $1.3 million previously described.

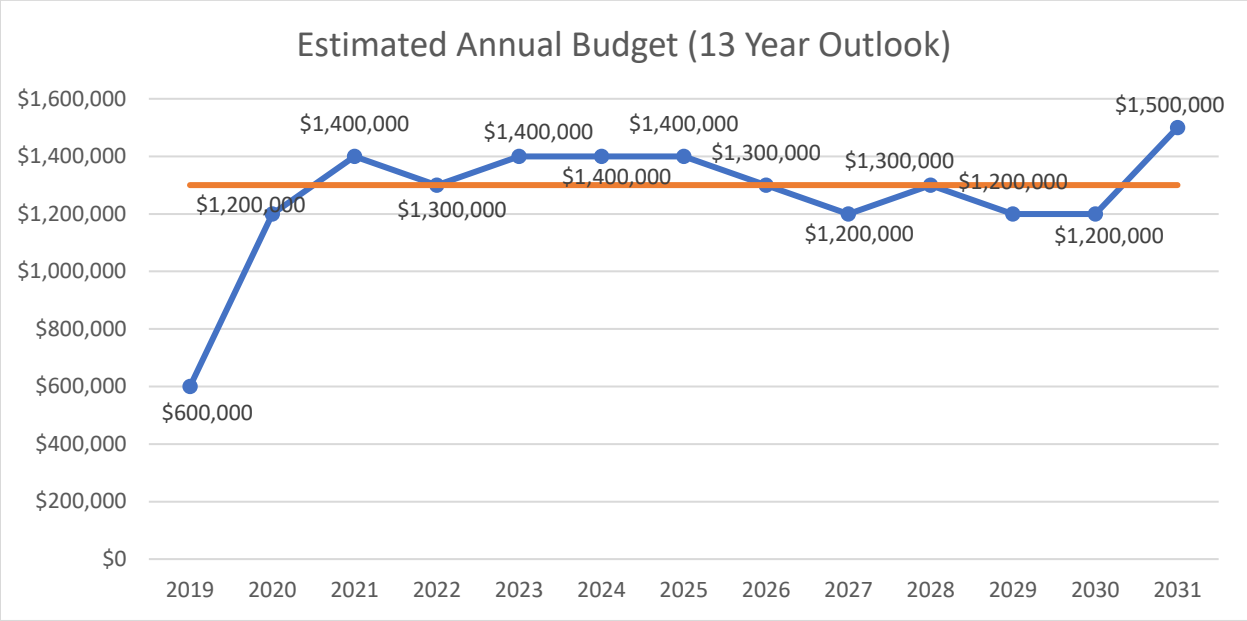


Figure 13 Estimated Annual Budget

Budget Recommendation

KL Engineering recommends that the City of West Allis prepare to budget between $1.5M and $2M annually for the next 13 years in an effort for convert all high-voltage series circuits with low pressure sodium luminaires in operation. The exact budget will fluctuate from year to year depending on circuits converted, and work force capabilities.

Upon completed conversion of all high priority circuits in 13 years, the City should reassess their streetlight budget because the minimum pace of 225 LPS luminaires per year will no longer apply. However, in that time HPS luminaires may also follow a similar path to its LPS counterpart, which may result in a new minimum pace of circuit conversions.

Additional Planning and Next Steps

KL Engineering has provided the City with a lighting system analyzer program, which can be used to develop a detailed budget and construction plan for the duration of the entire conversion process. This

study recommends that the City work to define lighting conversion construction projects and methodologies for the next 5 years in order to more efficiently allocate funds and City work forces. Future years beyond the next 5 can remain somewhat vague due to the unpredictability of resources but can be accounted for with the overall budget levels that our report indicates. Creation of a 5-year plan would formalize which circuits will be converted each year from 2020-2024 and whether the projects will be completed as part of City street projects, as part of WisDOT funded projects, or via stand-alone improvement (without street projects).

It is also recommended that the City work to create a “master plan” for low voltage electrical service and cabinet locations. A high-level version of this was started in the years prior to this study, which could be further defined and used as a guide moving forward. Mapping these cabinet locations would be useful for individual project planning and coordination between systems and the utility company. Additionally, creation of a master plan for low-voltage control cabinet locations would be a valuable reference to assist in coordinating the proposed City-wide 5G wireless communications network and will result in cost-savings as many future conflicts with design and construction could be mitigated.

Appendix A

Energy Consumption

Annual Energy Savings

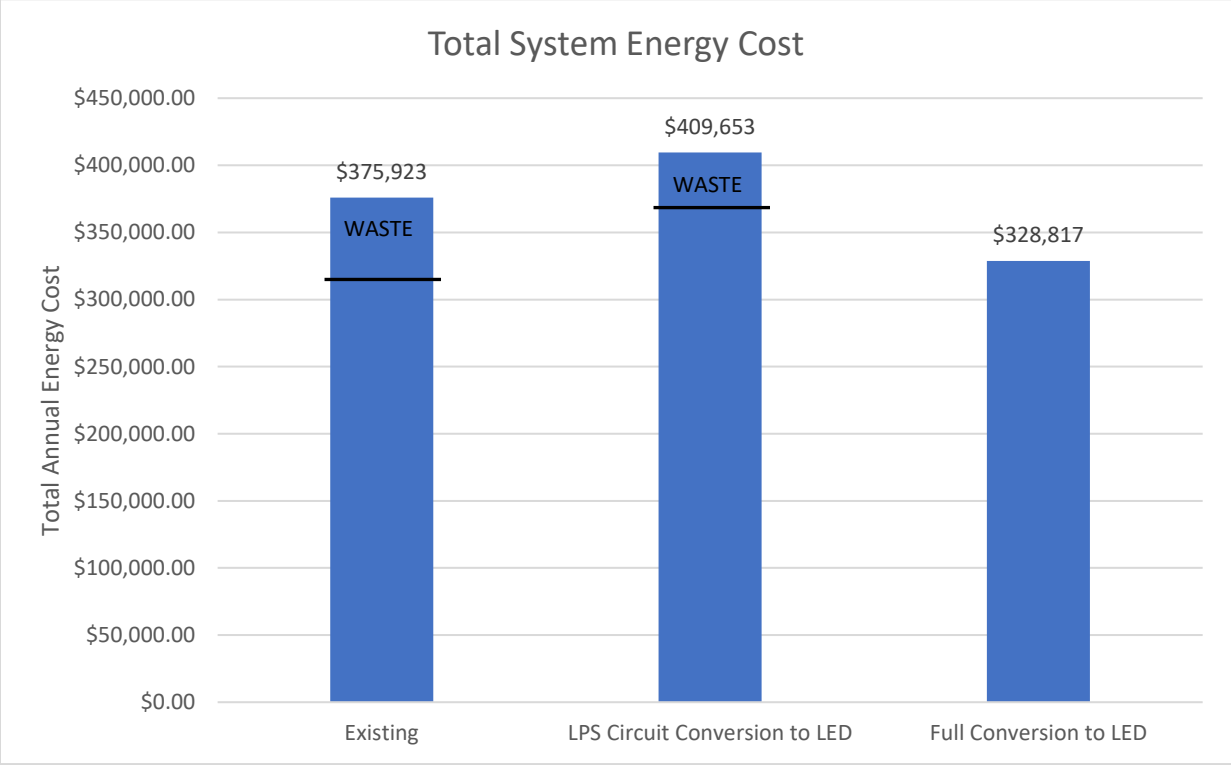
1) Assumes luminaires operate for 4,160 hours per year on average
2) Assumes electric cost of $0.125 per kilowatt hour

Existing Estimate

- Existing estimate applies the above parameters to all luminaires in operation.
- Assumes 25% Waste on HPS and LPS luminaires due to ballast and heat losses.

Proposed Estimate

- Applies above parameters to LED equivalent of all luminaires in operation
- LED equivalents are determined by approximate lumen output
- Savings from energy reduction cannot be applied as a credit to the annual budget



Appendix B

Maintenance Costs

Annual Maintenance Savings

1) Assumes current 4-man crew has 7,360 available for electrical maintenance and upgrades
    a. 85 days (2,720 hours) were spent performing series circuit conversions
    b. 26 days (832 hours) were spent responding to knock-downs
    c. That leaves 119 days (3,808 hours) for high and low voltage circuit maintenance of all luminaires

**This estimate does not include electrical maintenance of traffic signals, aside from knockdowns

2) From Milwaukee P3 study:
    a. Maintenance LET Projects = $351,315
    b. Milwaukee Co. Traffic Maintenance Agreement = 255,000
    c. Assume 50% of maintenance projects are for HPS luminaires
        i. $303,157.50 for maintenance of HPS luminaires
        ii. 8,148 HPS luminaires included in maintenance projects
    d. Maintenance cost per Milwaukee LET/agreement project HPS luminaire = $37.21
    e. Contractor Mark-up (based on West Allis city forces estimates) = 188% (use 175%)

3) West Allis Maintenance Cost per low voltage circuit luminaire
    a. HPS Luminaire = $21.26
    b. MH Luminaire = $21.26
    c. LED maintenance assumes 1/4 cost for lifespan = $5.32

4) Extrapolate cost per low voltage circuit luminaire to all low voltage luminaires in use
    a. 11 days (364 hours) spent on low voltage lighting systems
    b. That leaves 108 days (3,444 hours) spent on high voltage lighting systems
    c. 3,444 hours = $197,210.51 spent on high voltage lighting systems

5) Interpolate high voltage maintenance cost across all high voltage luminaires
    a. HV HPS luminaire = $37.44
    b. HV LPS luminaire = $37.44

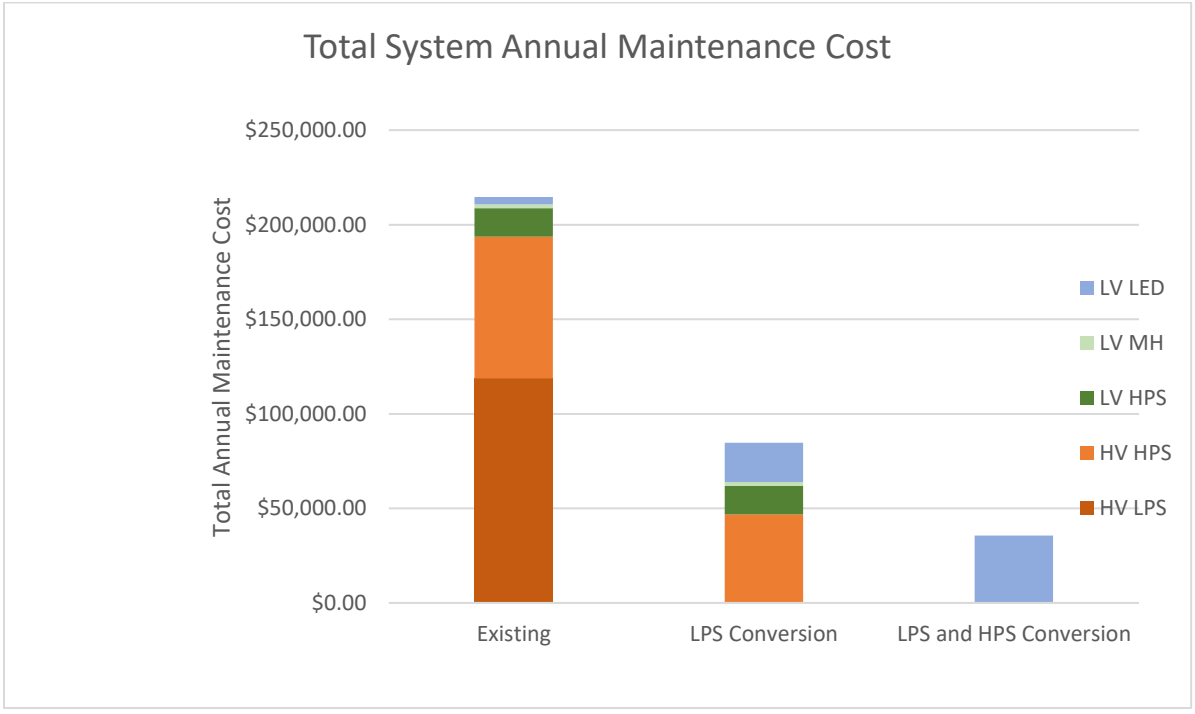
Existing Estimate

- Existing estimate applies the above parameters to all luminaires in use

Proposed Estimate

- Applies above parameters to LED equivalent of all luminaires in use
- LED equivalents are determined by approximate lumen output
- Savings from maintenance reduction cannot be applied as a credit to the annual budget

Maintenance Estimates										
Item	Total Available	Series Conversion		All Maintenance		Knockdown Maintenance		Estimated LV Maintenance Cost		Estimated HV Maintenance
Days Worked	230	85		145		26		11		108
Hours Worked per crew	7360	2720		4640		832		364		3444
Approximate Labor Cost	$421,433.60	$155,747.20		$265,686.40		$47,640.32		$20,835.57		$197,210.51
Maintenance Cost Per Unit										
	Circuits	LED Luminaires		HPS Luminaires		LPS Luminaires		MH Luminaires		Estimated Cost
	128 Total	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Annual
Low Voltage Circuits	51	740	$5.32	701	$21.26	0	N/A	94	$21.26	$20,835.57
High Voltage Circuits	77	0	$33.70	2043	$37.44	3224	$37.44	0	N/A	$197,210.51



Appendix C1

Construction Costs

Circuit Conversion – City Forces

1) Cost is based on information provided by the City for conversion of F-1 Circuit
2) City forces circuit conversion cost estimated at approximately $3,847.18 per luminaire

Streetlighting Analysis

Work Completed by Internal Staff

2/11/2019

Project Item	*City (Internal Staff) Cost*	
Boring w/Conduit		
City Boring - Labor	$60,343.20	
City Boring - Equipment (Vac-All/Rat Drill/New Boring Machine/Crane)	$53,319.80	
City Boring - Materials (Conduit - 14,509 ft. * $.75)	$10,882.50	
Boring Subtotal	**$124,545.50**	
Feeders for Distribution Circuits (3-#6 Copper conductors - 40,527 ft)		
City Materials - Wire	$1,200.00	
City Material - Cable	$16,380.00	
Feeders Subtotal	**$17,580.00**	
Decorative fixtures on National Avenue		
11 Fixture Heads, 22' Poles, Arms, Decorative Fitters, Banner Arms	**$50,000.00**	
Standard fixtures and poles		
City Materials - 82 Cree Fixture Heads, 4 - 20' Poles with Arms, 4 - 30' Used Poles with Arms	$21,114.48	**
New Fixtures and Poles Subtotal	**$21,114.48**	
Labor for new/relocated bases and poles and to wire poles		
Removal of Existing Pole and Base, Install New Base, Install New Pole, Install and Wire Fixture Heads (82)	**$60,343.20**	***
New Pull Boxes		
Install 6 Pull Boxes	**$5,390.00**	****
Previous Construction		
Random Portions of F1	**$67,336.84**	
CONSTRUCTION SUBTOTAL	**$346,310.02**	
PW (Dave and others) assist with design and to contract work	$1,860.80	
Engineering (Pete and others) assist with design and contract work	$2,296.32	
Consultant (design costs)	$15,000.00	
OVERALL TOTAL	**$365,467.14**	*****

* There are approximately 1,536,480 feet of boring left in the City-wide conversion project
** City would only need to purchase four (4) 20 foot poles as it already has an inventory of 30 foot poles to draw on
*** City is able to save a substantial amount of money by re-using bases
**** Contractor completes with a different method than City (open versus closed system) - both are acceptable solutions, however City method allows re-use of bases
***** Official Contractor bid = $599,256.50
****** City cost is for parts only as the labor is included with other labor costs included

Notes/Follow-Ups

1) Boring Machine - City Purchasing this year - Ave 15 year life - $200,000 +25% for maintenance - $16,667 / year cost - Included above

2) Approximate cost of portions of F1 that were completed by internal staff in advance of this project - $67,336.84

3) Average cost of a full circuit replacement outsourced (72 in the City Lighting System - one per year in annual CIP) - $685,750.46

4) Average cost of a full circuit replacement with City staff (72 in the City Lighting System - one per year in annual CIP) - $382,803.98

5) No rush to complete F1 at this time (National Ave. project is complete / currently more than 90% lit staff can light the other two streets and move on to 2019 projects first

6) If done internally, we could analyze streets projects and complete multiple streets on the same circuit when possible

7) Have ~72 circuits in City to convert (pieces of some are done with street projects)

Appendix C2

Construction Costs

Circuit Conversion – Contractor Forces

1) Cost is based on KL Estimate for contractor conversion of circuit D-5
2) Conversion cost based on most expensive scenario for conversion replacement
    a. Aluminum Poles and arms are 75% reusable
    b. Concrete and steel poles are 0% reusable
    c. Concrete Bases are 0% reusable
    d. 1 pull box per 10 luminaire
    e. 5% contingency
    f. 5% consultant cost
3) Contractor forces circuit conversion estimated at $7,791.65 per luminaire

LIGHTING ITEMS SUMMARY

PROJECT ID #: XXXX

West Allis - D5 Circuit

Milwaukee COUNTY

5/23/2019

LIGHTING	ITEM #	QUANTITY	UNIT	PRICE	AMOUNT
REMOVING CONRETE BASES	204.0195	104	EACH	$275.00	$28,600.00
CONDUIT SPECIAL 2-INCH	652.0605	17,500	LF	$20.00	$350,000.00
PULL BOX NON-CONDUCTIVE 24X42-INCH	653.0164	10	EACH	$1,250.00	$12,500.00
CONCRETE BASES TYPE 5	654.0105	104	EACH	$700.00	$72,800.00
CONCRETE CONTROL CABINET BASES TYPE L30	654.0230	4	EACH	$1,200.00	$4,800.00
ELECTRICAL WIRE LIGHTING 12 AWG	655.0610	10,608	LF	$0.60	$6,364.80
ELECTRICAL WIRE LIGHTING 6 AWG	655.0625	52,500	LF	$1.00	$52,500.00
ELECTRICAL SERVICE METER BREAKER PEDESTAL (CB100)	656.0200.001	4	LS	$1,250.00	$5,000.00
LUMINAIRES UTILITY LED B	659.1120	104	EACH	$350.00	$36,400.00
LIGHTING CONTROL CABIENTS 120/240 30-INCH	659.2130	4	EACH	$6,000.00	$24,000.00
REMOVE AND SALVAGE OR DISPOSE OF STREET LIGHT UNIT	SPV.0060.01	104	EACH	$250.00	$26,000.00
REINSTALL SALVAGED STREET LIGHT UNIT	SPV.0060.01	78	EACH	$500.00	$39,000.00
20' POLE AND ARM	SPV.0060.02	26	EACH	$1,200.00	$31,200.00
REUSING CONCRETE BASES	SPV.0060.02	0	EACH	$350.00	$0.00
TRAFFIC CONTROL	SPV.0105.01	1	LS	$7,500.00	$7,500.00
RESTORATION	SPV.0105.02	1	LS	$15,000.00	$15,000.00
HIGH VOLTAGE INFRASTRUCTURE REMOVAL	SPV.0105.03	1	LS	$25,000.00	$25,000.00
				CONSTRUCTION COST	$736,664.80
				CONTINGENCY - 5%	$36,833.24
				ENGINEERING - 5%	$36,833.24
				TOTAL COST	$810,331.28
				TOTAL COST PER LUMINAIRE	**$7,791.65**

Appendix C3

Construction Costs

Circuit Conversion – WE Energies Contract

1) Cost is based on KL Estimate for contractor conversion of circuit D-5
2) Conversion cost based on most expensive scenario for conversion replacement
    a. Aluminum Poles and arms are 0% reusable
    b. Concrete and steel poles are 0% reusable
    c. Concrete Bases are 0% reusable
    d. 1 pull box per 10 luminaire
    e. no control cabinets or meters
    f. 20% contingency - Assume there will be an extra mark-up for utilities contractor
    g. 8% engineering cost - Assume they will charge more for engineering
3) WE Energies will hire contractor forces to perform circuit conversions estimated at $9,322.64 per luminaire

LIGHTING ITEMS SUMMARY

PROJECT ID #: XXXX
West Allis - D5 Circuit
Milwaukee COUNTY
5/23/2019

WE Energies

Assumes WE energies installs everything new
Underground conduit and cable
Assumes WE energies can salvage poles

LIGHTING	ITEM #	QUANTITY	UNIT	PRICE	AMOUNT
REMOVING CONRETE BASES	204.0195	104	EACH	$275.00	$28,600.00
CONDUIT SPECIAL 2-INCH	652.0605	17,500	LF	$20.00	$350,000.00
PULL BOX NON-CONDUCTIVE 24X42-INCH	653.0164	10	EACH	$1,250.00	$12,500.00
CONCRETE BASES TYPE 5	654.0105	104	EACH	$700.00	$72,800.00
CONCRETE CONTROL CABINET BASES TYPE L30	654.0230	0	EACH	$1,200.00	$0.00
ELECTRICAL WIRE LIGHTING 12 AWG	655.0610	10,608	LF	$0.60	$6,364.80
ELECTRICAL WIRE LIGHTING 6 AWG	655.0625	52,500	LF	$1.00	$52,500.00
ELECTRICAL SERVICE METER BREAKER PEDESTAL (CB100)	656.0200.001	0	LS	$1,250.00	$0.00
LUMINAIRES UTILITY LED B	659.1120	104	EACH	$350.00	$36,400.00
LIGHTING CONTROL CABIENTS 120/240 30-INCH	659.2130	0	EACH	$6,000.00	$0.00
REMOVE AND SALVAGE OR DISPOSE OF STREET LIGHT UNIT	SPV.0060.01	104	EACH	$250.00	$26,000.00
REINSTALL SALVAGED STREET LIGHT UNIT	SPV.0060.01	0	EACH	$500.00	$0.00
20' POLE AND ARM	SPV.0060.02	104	EACH	$1,200.00	$124,800.00
REUSING CONCRETE BASES	SPV.0060.02	0	EACH	$5,000.00	$0.00
OVERHEAD SPAN WIRE	SPV.0090.01	0	LF	$5.00	$0.00
TRAFFIC CONTROL	SPV.0105.01	1	LS	$7,500.00	$7,500.00
RESTORATION	SPV.0105.02	1	LS	$15,000.00	$15,000.00
HIGH VOLTAGE INFRASTRUCTURE REMOVAL	SPV.0105.03	1	LS	$25,000.00	$25,000.00
			CONSTRUCTION COST		$757,464.80
			CONTINGENCY - 20%		$151,492.96
			ENGINEERING - 8%		$60,597.18
			TOTAL COST		$969,554.94
			TOTAL COST PER LUMINAIRE		**$9,322.64**

Appendix D1

City Labor Cost Estimates

Circuit Conversion – City Forces

1) Assumes all City electricians make $57.26 including benefits
2) Assumes 4-man crew is capable of (3) circuit conversions per year (46 weeks per year)
3) Construction oversight is considered incidental to 4-man crew

$57.26 * 8 * 5 * 46 * 4 / 3

= $140,477.87 per average circuit conversion

4) Luminaires per Average Circuit

Luminaire Type	HPS						LPS		MH	
Luminaire Wattage	50	70	100	150	200	250	35	55	250	70
Total Circuits with LPS luminaires	50									
Average Luminaires per Circuit	79									
% per Circuit	0%	4%	3%	12%	1%	0%	29%	52%	0%	0%
# per average LPS HV circuit	0	3	2	9	1	0	23	41	0	0

= $1,771 per luminaire

Appendix D2

City Labor Cost Estimates

Circuit Conversion – Contractor Forcers

1) Assumes all City electricians make $57.26 including benefits
2) Assumes contractor work will require 1 city electrician to provide construction oversight for entire circuit conversion project
3) Assumes contractor can complete 1 circuit conversion in 2 months (8 weeks)

$57.26 * 8 * 5 * 8

= $18,323.20 per average circuit conversion

4) Luminaires per Average Circuit

Luminaire Type	HPS						LPS		MH	
Luminaire Wattage	50	70	100	150	200	250	35	55	250	70
Total Circuits with LPS luminaires	50									
Average Luminaires per Circuit	79									
% per Circuit	0%	4%	3%	12%	1%	0%	29%	52%	0%	0%
# per average LPS HV circuit	0	3	2	9	1	0	23	41	0	0

= $231 per luminaire

Appendix D3

City Labor Cost Estimates

Circuit Conversion – WE Energies Contract

1) Assumes all City electricians make $57.26 including benefits
2) Assumes contractor work will require 1 city electrician to provide construction oversight for entire circuit conversion project
3) Assumes contractor can complete 1 circuit conversion in 2 months (8 weeks)

$57.26 * 8 * 5 * 8

= $18,323.20 per average circuit conversion

4) Luminaires per Average Circuit

Luminaire Type	HPS						LPS		MH	
Luminaire Wattage	50	70	100	150	200	250	35	55	250	70
Total Circuits with LPS luminaires	50									
Average Luminaires per Circuit	79									
% per Circuit	0%	4%	3%	12%	1%	0%	29%	52%	0%	0%
# per average LPS HV circuit	0	3	2	9	1	0	23	41	0	0

= $231 per luminaire

Appendix E

References and Resources

Street Lighting Master Plan Reference Materials

1) City of Milwaukee Series Circuit Master Plan (completed in 2009 by Robert M. La Follette School of Public Affairs)
2) Internet research and other contacts with street lighting conversion projects:
    a. Detroit, MI
    b. Atherton, CA
    c. Huntington Beach, CA
    d. 5G system implementations (multiple examples across the USA)
    e. OV20 low-voltage transformers (vendor contact)

City of West Allis Data

1) GIS database information
    a. Lighting system mapping and control locations
    b. Luminaire inventory data
2) Operations data
    a. Electrical department staff levels and available equipment
    b. Typical workload and maintenance activities
3) Other data
    a. Example plans and specifications for high-voltage conversion project
    b. CIP budget estimates prepared by City staff for F-1 conversion
    c. 5-year CIP project summary

Planning Study Coordination

1) Study was coordinated with a group of City staff and stakeholders
    a. Peter Daniels & Traci Gengler – Engineering
    b. David Young & Don Molleson – Operations
    c. Mike May & Kevin Haass – City Alders
    d. Participation from several others was included at lesser levels of involvement
2) 4 progress meetings and included 1 presentation to City elected officials
    a. 4/18/19 – Kickoff meeting
    b. 5/23/19 – 1st draft of alternatives review meeting
    c. 7/1/19 – Final alternatives review meeting
    d. 8/28/19 – Study conclusions review meeting
    e. 9/3/19 – Committee of the Whole presentation