

**BEFORE THE PUBLIC SERVICE COMMISSION  
OF THE STATE OF MISSOURI**

In the Matter of Union Electric Company d/b/a            )  
Ameren Missouri's LED Street Lighting Update        )       File No. ET-2016-  
and Tariff Filing.    )

**LED LIGHTING UPDATE FILING**

COMES NOW Union Electric Company d/b/a Ameren Missouri (Ameren Missouri or Company) and for its LED Lighting Update filing, states as follows:

1. In File No. ER-2014-0258, a *Nonunanimous Stipulation and Agreement Regarding MEEIA Low Income Exemption and LED Streetlighting Issues* (Stipulation) was filed on March 12, 2015. The Stipulation was approved by the Missouri Public Service Commission (Commission) effective March 21, 2015.

2. In the Stipulation, Ameren Missouri agreed to continue updating its evaluation of the cost effectiveness of company-owned LED street and outdoor area lighting, consistent with the updates that had been being provided in File No. EO-2013-0367.

3. Attached to this pleading is Ameren Missouri's LED Lighting Update Report for 2015, in compliance with the above-cited order.

4. This is the third annual evaluation of cost effectiveness for LED lighting that Ameren Missouri has completed. This year, for the first time, the outcome shows that LED street lighting is cost effective for a large portion of Ameren Missouri's street lights. Accordingly, the Company has a plan to convert its enclosed and open bottom street lighting facilities to LED over the next five years. Enclosed and open bottom lights constitute 66% of the Company-owned lights. The Company will do the conversions as part of its routine maintenance, thus installing LED lights in a least-cost manner.

5. Essentially and concurrent with this filing, Ameren Missouri is filing a revised street lighting tariff to reflect a lower monthly rate for LED street lights than the rate that is currently charged for non-LED street lights. The lower rate reflects the variable cost savings associated with the LED street lights.

6. Ameren Missouri requests that the Commission also find the conditions of the stipulation have been satisfied and that no further LED reports need to be submitted.

**WHEREFORE**, Ameren Missouri respectfully asks the Commission to accept the attached LED Lighting Update Report and to either approve or allow the associated tariff sheets to go into effect on January 16, 2016. Ameren Missouri also requests the Commission order that the conditions of the Stipulation have been satisfied and that no further LED reports need to be submitted.

Respectfully submitted,

UNION ELECTRIC COMPANY  
d/b/a Ameren Missouri

*/s/ Wendy K. Tatro*

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**Wendy K. Tatro**, # 60261  
Director & Assistant General Counsel  
Ameren Missouri  
1901 Chouteau Avenue  
St. Louis, MO 63103  
(314) 554-3484 (phone)  
(314) 554-4014 (fax)  
[AmerenMOService@ameren.com](mailto:AmerenMOService@ameren.com)

**CERTIFICATE OF SERVICE**

The undersigned certifies that true and correct copies of the foregoing have been e-mailed or mailed, via first-class United States Mail, postage pre-paid, to the service list of record this 17<sup>th</sup> day of December, 2015.

*/s/ Wendy K. Tatro* \_\_\_\_\_  
Wendy K. Tatro

# Light Emitting Diode (LED) Street and Outdoor Area Lighting Report

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December 2015



## Executive Summary

### Key Insights

- The price of LED fixtures continues to decline as manufacturing volumes increase.
- About two-thirds of the Company-owned street and outdoor area lights now have LED alternatives that are technically and economically feasible.
- The Company plans to install approximately 25,000 enclosed and open bottom LED lights per year over a period of approximately five years beginning in the 2nd quarter of 2016.
- Rates for the most common LED lights will be about \$1 per month less than the current lighting offerings, which is nearly a 10% reduction in the monthly charge.
- Conversion of the enclosed and open bottom lights to LED will, once complete, result in a reduction of approximately 62,000 MWH in energy use and almost 60,000 metric tons of carbon production annually.

If approved by the Missouri Public Service Commission, Ameren Missouri will begin implementing LED lighting for its enclosed and open bottom light types beginning in the 2nd quarter of 2016 with full conversion of those light types anticipated in five years. These two light types represent 66% of all Company-owned lights. This aggressive approach will require the installation of roughly 25,000 LED fixtures per year, and once conversion is complete, will result in the realization of reduced energy consumption of 62,000 MWH per year and reduced carbon production of almost 60,000 metric tons per year. Both customer rates and the associated Fuel Adjustment Charge (FAC) costs will be lower than for the traditional Rate 5M offerings resulting in customer savings of \$1.9 million per year once complete.

### Technology Assessment Update

LED lighting technology has been experiencing three major trends in recent years. Prices have been decreasing, efficiency and rated life have been increasing and color temperatures have become “warmer.” In addition, a recent Ameren competitive bidding event indicated that pricing for traditional street and outdoor area lighting products (High Pressure Sodium, “HPS”) has increased and will continue to increase in the future.

Price decreases for LEDs have been dramatic over the period 2013-2015 for enclosed and open bottom lights (the most common types) with prices declining from 5%-15% from 2014 to 2015. The total decrease for LED street and outdoor area lighting from 2013 to 2015 is in the 25%-50% range. The primary driver appears to be increased production volumes, though manufacturing and design improvements are also major factors. Many manufacturers are now producing their second generation of enclosed and open bottom LEDs and some are already producing their third generation designs. While the price reductions appear to be flattening for these lights of advanced design, it is possible that substantial price improvements could still be recognized in the future for directional and post top (decorative) lighting that have not progressed as dramatically.

The efficiency improvement in LED street and outdoor area lighting products, while substantial, is not as large of a factor in making lights economic as the overall price declines. However, manufacturers recognize that a primary benefit of LED technology can be reliability improvements, and the rated life expectancy of many products has increased substantially compared to a few years ago. Many LED products now have a rating of 100,000 hours under the Illuminating Engineering Society’s (IES) technical standard TM-21, which means that the LED component of the fixture will still be producing 70% of its original design light level after 100,000 hours of operation. A limitation of the standard is that it only applies to the light producing portion of the fixture, the LEDs themselves, and does not provide any guidance as to whether the other components will continue

to function, without maintenance, for that length of time. However, manufacturers are providing total product warranties of five and sometimes 10 years.

Color “temperature” is a characteristic of visible light that describes its hue or tone and is rated in degrees Kelvin. Color temperatures up to 3000K are considered “warm.” “Cool” light is between 3000K and 4500K, and “daylight” is between 4500K and 6500K. Just a few years ago, most LEDs had a rating in the “daylight” range. Today, LEDs are readily available in the “cool” range and “warm” LEDs are expected in the near future.

The relevance of the change in LED color temperature is directly related to Ameren Missouri’s intent to replace existing “warm” high-pressure sodium (2200K) and “cool” mercury vapor lights (4000K) with “cool” LEDs of 4000K as the traditional lights require maintenance. From a technical perspective, the color temperature produced by the LED lights Ameren Missouri expects to purchase will be very similar to the existing mercury vapor (MV) lights, which have been intermixed with high pressure sodium (HPS) lights on the Ameren Missouri system for decades. However, unlike the prior transition from MV to HPS, which is ongoing to this day, the transition of enclosed and open bottom lights to LED’s will be completed in just a few years. The “daylight” rating of older LEDs was a significant factor in early adopters electing to deploy LEDs through geographic conversion. With the advent of “cool” LEDs, Ameren Missouri does not face that constraint.

The ability of the human eye to see color is dependent on the nature of the light source. A low Color Rendition Index (CRI) offers limited ability to recognize different colors and a high CRI provides good differentiation. Traditional HPS lights have both a poor CRI and also make everything appear yellow. LEDs have a superior CRI that is closer to natural light than almost any other light source and have nearly eliminated the blue tint that was associated with early LEDs.

While lumens is a common way to describe lighting, the lumen rating of traditional and LED street and outdoor area lighting technologies is not comparable because the lumen rating is based upon the total amount of light created rather than the amount of light that is useful. Traditional technologies generally create light in all directions and then use reflectors and lenses to redirect light that would not otherwise be useful in a direction that it will become useful. LED lights actually create light in a particular direction resulting in a greater percentage of the electricity converted to light being useful and increasing the efficiency of LED as a light source.

### **Cost Effectiveness Analysis**

The cost effectiveness analysis performed for LED street and outdoor area lights compared the additional up-front cost of LED street and outdoor area lighting fixtures to the additional benefits of those LEDs over their expected useful life. If the additional benefits of LED street and outdoor area lights are greater than the additional costs then conversion is cost effective; it is then also important to understand the period of time that passes before the benefits outweigh the costs.

If an Ameren Missouri worker is already at a light because that light requires maintenance, the additional up-front cost to install an LED light is simply the cost of the LED fixture above the expected cost to repair the fixture. Because the benefits accrue over the life of the LED street and outdoor area lights, the incremental up-front cost is compared to the present value of the lifetime benefits.

The benefits of LED street and outdoor area lights include 1) the avoided energy costs associated with the lower energy consumption of LED street and outdoor area lights and 2) the avoided maintenance costs associated with the expectation that only a very small percentage of LED fixtures will require a maintenance trip to their location during the first 15 years of their life. The avoided energy costs are the difference between the input watts of the existing light less the input watts of the comparable LED light with the result multiplied by the expected annual



operating hours (4,000) and the future avoided energy rates from Ameren Missouri's 2014 IRP filing in File No. EO-2015-0084. The avoided maintenance costs are the cost of replacing bulbs and/or photocells on traditional lights every five years on average. Since it cannot be known whether any particular bulb will last longer or less than its rated life, it was estimated that all bulbs, on average, burn out at approximately their rated life. Thus, the avoided maintenance savings accrue in "steps" at intervals equal to the rated life of traditional bulbs.

With respect to enclosed and open bottom street and outdoor area lights, the results included in Appendix A indicate that 95% of the HPS lights installed, once converted to LED, become cost effective on or before the second time that maintenance would have been required (11 years), and two-thirds of the MV lights installed, once converted to LED, will become cost effective on or before the first time that maintenance would have been required (6 years). MV lights become cost effective sooner than HPS lights because they use more energy.

Conversion of directional and decorative post top lights is not cost effective at this time. The number of manufacturers offering LED directional fixtures is more limited and the costs have not declined to the same degree as for enclosed and open bottom LEDs. Post top LED fixtures, while readily available, still have a very high price premium compared to traditional post top fixtures, which is likely due to much smaller production volumes. In addition, many of the current post top products have a rated life expectancy that is far lower than enclosed and open bottom LEDs. Ameren Missouri will continue to monitor the evolution of directional and post top LED products so that they can be offered to customers when they become cost effective.

The benefit to customers of deploying LED street and outdoor area lighting when a traditional light requires maintenance cannot be overemphasized. A geographic deployment strategy would necessarily mean that the portions of the lighting system that have not been converted to LED would still need to be maintained by replacing traditional lighting technologies with traditional lighting technologies;

thus missing the most economic opportunities for LED conversion. Further, making a special trip to the pole to replace a light that is still in working condition increases the incremental cost and risk of deploying LEDs, particularly during the early years of implementation. Although it is possible that some operational efficiencies may be gained through a geographic deployment strategy, those gains would need to be significant enough to overcome the cost savings of the replace on failure approach. In addition, the uncertainty regarding the ability to achieve the necessary efficiencies results in additional risk associated with geographic deployment that does not exist under a replace on failure approach. In addition, a geographic deployment strategy relies on picking and choosing the areas to convert to LED. Relying on light failures to prompt LED replacements eliminates any perceived favoritism that might be alleged in a geographic deployment strategy especially since customers will recognize bill savings from the time that LED street and outdoor area lights are installed. By installing LED technology as the traditional lights require maintenance, compared to geographic conversion of working lights, customers will directly benefit from the most economic approach, a fair transition plan, and efficient use of Ameren Missouri resources. Even so, commencing LED deployment under a replace on failure approach does not preclude Ameren Missouri from undertaking a geographic deployment strategy in the future or even combining both approaches as implementation conditions evolve.

### **Customer Rates**

Concurrent with this report Ameren Missouri has filed the attached 5M Street and Outdoor Area Lighting – Company-owned tariff. The tariff includes four new LED options and a revision of the provision that allows lighting customers to elect for conversion of their existing light to a different Ameren Missouri offering.

The four new LED options are outlined in the table below. In short, they represent an LED equivalent for each size of currently available horizontal enclosed lighting option as well as an LED equivalent for the predominant open bottom lighting

option. These LED options are based on the cost effectiveness analysis presented earlier in this document.

	<b>LED Input Watt Range (1)</b>	<b>Existing Technology Lumens</b>	<b>LED Annual kWh</b>	<b>Existing Technology Annual kWh</b>
<b>Horizontal Enclosed</b>	40-50	HPS: 9,500 MV: 6,800	180	HPS: 468 MV: 824
<b>Horizontal Enclosed</b>	90-110	HPS: 25,500 MV: 20,000	420	HPS: 1,224 MV: 1,908
<b>Horizontal Enclosed</b>	180-220	HPS: 50,000 MV: 54,000	840	HPS: 1,892 MV: 4,380
<b>Open Bottom</b>	40-50	HPS: 5,800 HPS: 9,500 MV: 3,300 MV: 6,800	180	HPS: 340/468 MV: 472/824

(1) Since lumens are not comparable between LED and traditional technologies, Ameren Missouri will classify LEDs according to a range of input watts to accommodate small changes in variability between manufacturers or improvements in LED efficiency over time.

It is important to recognize that the LED alternatives use 55-65% less energy than the existing lighting options offered by Ameren Missouri. After about five years approximately 66% of the lighting system will be converted to LEDs. This will reduce the total 5M rate class energy consumption by more than 40%. This reduction in kWh will have a material impact on the fixed costs allocated to the 5M rate class in a future class cost of service study. Ameren Missouri’s tariff is predicated on the changes in key variable costs between the two lighting technologies. Those two variable costs are 1) the reduction in net base energy costs and 2) the reduction in maintenance costs. The table below demonstrates the calculation of the LED rates that are incorporated in the draft tariff.

	<b>Reduction in Monthly Net Base Energy Cost (1)</b>	<b>Monthly Maintenance Cost in Current HPS Rate</b>	<b>Total Reduction in Variable Costs</b>	<b>Current HPS &amp; MV Rates</b>	<b>Proposed LED Rate (% Reduction)</b>
<b>Horizontal Enclosed</b> 50-60 W	\$0.44	\$0.62	\$1.06	\$12.41	<b>\$11.35 (8.5%)</b>
<b>Horizontal Enclosed</b> 140-160 W	\$1.24	\$0.62	\$1.86	\$17.93	<b>\$16.07 (10.4%)</b>
<b>Horizontal Enclosed</b> 240-260W	\$1.62	\$0.62	\$2.24	\$31.97	<b>\$29.73 (7.0%)</b>
<b>Open Bottom</b> 40-50 W	\$0.44	\$0.62	\$1.06	\$10.98	<b>\$9.92 (9.7%)</b>

(1) The monthly Net Base Energy Cost used for pricing LEDs is based on the HPS lighting technology because the HPS lighting technology is the current lighting technology being installed and because MV rates have been set to match the equivalent HPS light.

In addition to the reduction in the monthly base charges above, the LED alternatives will result in a reduction in Fuel Adjustment Charges (“FAC”) on monthly bills. Because the FAC charges are assessed on a per kWh basis and LEDs use much less energy compared to existing HPS and MV lights, the FAC savings will be relatively substantial. The table below quantifies the expected monthly savings based on the currently effective FAC rate.

	<b>Reduction in Annual kWh</b>	<b>Monthly FAC Savings (1)</b>	<b>Total Monthly Savings</b>	<b>% Monthly Savings</b>
<b>Horizontal Enclosed</b>				
HPS 9,500	288	\$ 0.05	\$ 1.11	8.9%
MV 6,800	644	\$ 0.10	\$ 1.16	9.3%
HPS 25,500	804	\$ 0.13	\$ 1.99	11.1%
MV 20,000	1,488	\$ 0.24	\$ 2.10	11.7%
HPS 50,000	1,052	\$ 0.17	\$ 2.41	7.5%
MV 54,000	3,540	\$ 0.58	\$ 2.82	8.8%
<b>Open Bottom</b>				
HPS 5,800	160	\$ 0.03	\$ 0.16	1.6%
MV 3,300	292	\$ 0.10	\$ 0.05	1.8%
HPS 9,500	288	\$ 0.05	\$ 1.11	10.1%
MV 6,800	644	\$ 0.10	\$ 1.16	10.6%

(1) Based on FAC Rate effective February 2016 through May 2016 of \$0.00195.

Notwithstanding the similarity of LED color temperature to Ameren Missouri's existing mercury lighting, there may be some customers that may be sensitive to the appearance of LEDs and sodium lighting adjacent to one another. As in the past, a customer can request that a particular fixture(s) be converted to a different light offered by Ameren Missouri by paying a \$100 per fixture conversion fee contained in Rate 5M. This provides Ameren Missouri customers with an avenue to elect faster, geographic, deployment of LED lighting than would otherwise occur under Ameren Missouri's implementation timeline. As a result of the short transition period, Ameren Missouri does not expect a significant number of early conversion requests. Nonetheless, to ensure a manageable process, Ameren Missouri will accept requests totaling up to 1,000 fixtures per calendar year and up to 25 fixtures per customer account per calendar year.

### Implementation Timing

Beginning LED lighting installations in the 2<sup>nd</sup> quarter of 2016 will require that Ameren Missouri move on an aggressive timeline to 1) evaluate specific products/vendors, 2) competitively bid the LED product types targeted for implementation and secure contracts with a vendor(s), 3) build necessary inventory levels consistent with vendor lead times, 4) draw down inventory of discontinued sodium and mercury light stock 5) educate customer service personnel on the new LED lighting offerings and proper application, and 6) educate operations personnel on proper LED installation and process changes necessary to support material tracking and customer billing.

In fact, based on work performed in previous LED street and outdoor area lighting reports and anticipated further cost reductions in LED technology, Ameren Missouri began this process mid-2015. At that time, in conjunction with updating the cost effectiveness analysis of LED street and outdoor area lighting, potential vendors were invited to present educational and technical information about LED lighting technology and the current state and direction of the market, in general, and about their LED products specifically. Material specifications were then completed and the competitive bidding process was launched in late October 2015 with a target of selecting preferred vendor(s) by the end of 2015 and having contracts in place by mid-February 2016. Initial indications are that building inventory quantities necessary to launch LED installations will require approximately 6-8 weeks considering vendor lead times. Drawdown of traditional lighting inventory levels has already begun. Education and training of Ameren Missouri customer service and operational employees is expected to begin in February and March of 2016.

### Conclusions

The economic analysis demonstrates that it is now cost effective to transition horizontal enclosed and open bottom style lights to LED alternatives. An important aspect of the economic analysis is that the lights are converted to LEDs on an “as fail” basis. Leveraging the fact that a worker would already be

visiting the location of a failed light lowers the cost of conversion. Ameren Missouri believes the savings in costs with this implementation approach and the immediate bill savings to customers will outweigh the medium-term mixing of lighting differences between HPS and LED technologies. As existing lights fail and new lights are installed, customers will immediately save approximately 10% per month for the new LED lights. After five years of implementation, nearly all of the 125,000 horizontal enclosed and open bottom style will be replaced with LEDs in the most cost effective manner. While post top and directional style lights are not cost effective today, Ameren Missouri will continue to evaluate the economics of these light types and look for future implementation opportunities as these products evolve.

Appendix A

Light Style	Light Type	Lumens	Input Watts	Quantity Installed	Fixture Replacement Cost (\$)			NPV Maintenance Savings (\$)		NPV of Energy Benefits	Total Net Benefit of LED	Payback (Yrs)
					Repair Existing	LED Install Cost	LED Additional	Second Trip	Third Trip			
Enclosed	HPS	9,500	117	17,827	\$ 65.22	\$ 208.68	\$ 143.46	\$ 53.67	\$ 98.02	\$ 113.80	\$ 68.36	11
	HPS	25,500	306	14,315	\$ 66.57	\$ 290.91	\$ 224.34	\$ 54.93	\$ 100.46	\$ 317.70	\$ 193.82	9
	HPS	50,000	473	3,003	\$ 66.85	\$ 499.98	\$ 433.14	\$ 55.20	\$ 100.96	\$ 415.70	\$ 83.52	12
	MV	6,800	206	7,770	\$ 60.65	\$ 208.68	\$ 148.03	\$ 49.41	\$ 89.78	\$ 254.48	\$ 196.22	6
	MV	20,000	477	3,800	\$ 63.40	\$ 290.91	\$ 227.51	\$ 51.98	\$ 94.74	\$ 587.98	\$ 455.21	6
	MV	54,000	1095	75	\$ 78.70	\$ 499.98	\$ 421.29	\$ 66.26	\$ 122.34	\$ 1,398.83	\$ 1,099.89	5
Open Bottom	HPS	5,800	85	106	\$ 63.93	\$ 207.16	\$ 143.23	\$ 52.47	\$ 95.69	\$ 63.22	\$ 15.69	12
	HPS	9,500	117	58,880	\$ 65.23	\$ 207.16	\$ 141.93	\$ 53.68	\$ 98.04	\$ 113.80	\$ 69.91	11
	MV	3,300	118	2,901	\$ 66.26	\$ 207.16	\$ 140.90	\$ 54.65	\$ 99.90	\$ 115.38	\$ 74.38	11
	MV	6,800	206	16,201	\$ 60.65	\$ 207.16	\$ 146.51	\$ 49.41	\$ 89.78	\$ 254.48	\$ 197.74	6
Post top	HPS	9,500	117	42,675	\$ 65.23	\$ 469.53	\$ 404.30	\$ 53.68	\$ 98.04	\$ 108.67	\$ (197.60)	NA
	MV	3,300	118	99	\$ 66.26	\$ 469.53	\$ 403.27	\$ 54.65	\$ 99.90	\$ 110.25	\$ (193.13)	NA
	MV	6,800	206	8,999	\$ 60.65	\$ 469.53	\$ 408.88	\$ 49.41	\$ 89.78	\$ 249.34	\$ (69.77)	NA
Directional	HPS	25,500	306	3,561	\$ 66.57	\$ 496.66	\$ 430.09	\$ 54.93	\$ 100.46	\$ 317.31	\$ (12.33)	NA
	HPS	50,000	473	3,764	\$ 66.85	\$ 626.32	\$ 559.47	\$ 55.20	\$ 100.96	\$ 478.53	\$ 20.02	15
	MH	34,000	450	5,232	\$ 70.80	\$ 567.57	\$ 496.77	\$ 58.88	\$ 108.09	\$ 544.91	\$ 156.23	11
	MH	100,000	1077	951	\$ 78.30	\$ 953.48	\$ 875.19	\$ 65.88	\$ 121.62	\$ 1,097.46	\$ 343.90	11
	MV	20,000	294	302	\$ 66.80	\$ 496.66	\$ 429.86	\$ 55.15	\$ 100.87	\$ 587.59	\$ 258.60	10
	MV	54,000	1095	23	\$ 78.70	\$ 626.32	\$ 547.62	\$ 66.26	\$ 122.34	\$ 1,461.66	\$ 1,036.38	6

HPS = High Pressure Sodium

MV = Mercury Vapor

MH = Metal Halide

NA = Does not pay back in first 15 years.

All Lights	190,484
Enclosed & Open Bottom	124,878