The Empire District Electric Company
LED Street Lighting Pilot Summary

Pilot Purpose

In Docket No. ER-2012-0345, The Empire District Electric Company ("Empire") agreed to conduct a Light Emitting Diode ("LED") Street Lighting Pilot to study the overall suitability, feasibility and community acceptance of LED street light fixtures versus existing High-Intensity Discharge ("HID") street light fixtures.

Pilot Scope

The LED Street Lighting Pilot tracked by Empire served to verify the mortality rate of the LED bulb, LED street light energy usage, and finally the maintenance costs of LED street lighting fixtures. The LED street lighting pilot program had an initial time frame of three (3) years, beginning in August 2014. The Pilot stipulated that it would be limited to five locations in five different municipalities within Empire's Missouri service territory. These locations were limited to two (2) blocks of continuous roadway with connecting areas of principal traffic generation within the cities.

Pilot Implementation

Existing HID street lighting fixtures and photocontrols were replaced with LED street lighting fixtures and long life photocontrols at each location. When necessary, new poles with additional fixtures were installed to meet RP8 lighting standards. The Illuminating Engineering Society ("IES") of North America provides recommended roadway design criteria in its document called Recommended Practice 8, Roadway Lighting ("RP8"). Fixtures below 150W do not provide enough light output to meet RP8 standards and fixtures above 400W are rarely used for roadway lighting. Based on this, the LED fixtures chosen for the pilot were limited to 150W and/or 250W High Pressure Sodium ("HPS") equivalents. The implementation costs of the pilot project were tracked and the energy usage of the new LED street light fixture was metered at each pilot location. As required by the LED Street Lighting Pilot project terms, Empire charged identical rates as the HID street light fixtures.

Pilot Material Selection

Based on product quality and previous work experience using HPS light fixtures, Empire chose American Electric Lighting as the manufacturer for the LED street lighting fixtures. The LED light fixture ATB0 was chosen as the 150W HPS equivalent fixture, and the LED light fixture ATB2 was chosen as the 250W HPS equivalent fixture. A primary driver for choosing these specific fixtures was based on the delivered street side and house side lumens of each fixture type. A comparison is shown in Table 1 below.

Table 1 – Delivered Lumens Comparison

FIXTURE TYPE	150W HPS	ATB0	250W HPS	ATB2
STREET SIDE LUMENS	7,502	5,723	12,367	10,111
HOUSE SIDE LUMENS	3,450	1,649	7,357	2,809

Note that the table above uses 2014 lumen output data to match the LED lighting fixtures purchased. The lumen output has subsequently improved on the ATB0 and ATB2 since 2014.

Empire initially planned to utilize both "Ripley" and "Dark To Light" as the preferred long life photo control manufacturers for the LED street lighting pilot. Both of the manufacturer's photocontrols are rated with a 20 year life. The Ripley photocontrol has a lower surge protection rating of 640J at 40kA, but uses zero cross switching. The Dark To Light photocontrol has a higher surge protection rating of 1,280J at 40kA, but does not offer zero cross switching. The goal was to test both photocontrol manufacturers during the pilot. However, the Dark To Light photocontrols were backordered at the time, and only Ripley photocontrols were installed.

Pilot Material Cost

Table 2 reflects the 20 year life cycle of certain costs of the LED street lighting fixture and photocontrol compared to an equivalent HPS fixture and photocontrol.

Table 2 – 20 Year Life Cycle Cost Comparison

FIXTURE	INSTALL COST	4YRS	8YRS	12YRS	16YRS	TOTAL COST
150W HPS	$158.63	$31.83	$82.56	$40.32	$104.58	$417.92
ATB0	$363.93	$0.00	$0.00	$0.00	$0.00	$363.93
250W HPS	$208.64	$32.17	$80.81	$40.75	$102.37	$464.74
ATB2	$514.80	$0.00	$0.00	$0.00	$0.00	$514.80

Note: Table 2 above includes material cost, labor capitalization rates, equipment costs and general overhead cost allocations based on pilot data as of 2017. Mounting brackets, mounting hardware, cable, and connectors are not included, as these costs would be the same cost regardless of which type of fixture and photocontrol type is used. In addition, an annual inflation rate of 3% was assumed for material, labor, and equipment. Due to the unpredictability and uncertainty of labor and equipment costs for travel to and from the light fixture for each maintenance event were not included. When travel costs are factored in, the overall life cycle cost of a HPS fixture could increase costs significantly. Based on prior maintenance event history of the HPS light fixtures, it is assumed that a standard photocontrol and light fixture are replaced every 4 years, and that on an 8 year interval, a HPS starter would need to be replaced.

Pilot Energy Usage

The main goal of the LED Street Light pilot was to provide the necessary illuminance on the target areas with the best lighting quality using the lowest possible energy consumption. To calculate the projected monthly and annual kWh values for a LED street light fixture and HPS street light fixture, the anticipated burn hours were used. To determine the anticipated burn hours, the daily sunrise and sunset times were utilized which are based on data provided by the US Naval Observatory. The specific LED street lighting photocontrols purchased for this pilot are designed to turn on approximately 16 minutes after sunset and turn off approximately 13.5 minutes after sunrise. Utilizing the run time specifications of the LED street

lighting photocontrols and the US Naval sunrise and sunset time, Empire calculated the estimated monthly and annual burn hours for Joplin and Branson, which were then averaged together to get a system wide estimate for Missouri. Table 3 below shows the estimated burn hours for Empire's service territory in Missouri.

Table 3 – Estimated Burn Hours for Missouri Service Territory

MONTH	BURN HOURS (JOPLIN)	BURN HOURS (BRANSON)	BURN HOURS (AVERAGE)
JANUARY	419.85	419.23	419.54
FEBRUARY	355.07	354.31	354.69
MARCH	357.91	357.48	357.70
APRIL	310.59	311.13	310.86
MAY	289.86	290.90	290.38
JUNE	265.37	266.65	266.01
JULY	281.83	283.08	282.46
AUGUST	308.99	309.70	309.35
SEPTEMBER	333.35	333.04	333.20
OCTOBER	380.56	380.16	380.36
NOVEMBER	398.96	398.34	398.65
DECEMBER	429.09	427.87	428.48
TOTAL	**4,131.43**	**4,131.89**	**4,131.68**

Using the estimated average burn hours, the projected monthly and annual kWh per LED light fixture and HPS light fixture were determined. Table 4 below shows these results.

Table 4 – LED Light Fixture VS HPS Light Fixture kWh Comparison

FIXTURE	INPUT WATTS	JAN KWH	FEB KWH	MAR KWH	APR KWH	MAY KWH	JUN KWH	JUL KWH	AUG KWH	SEP KWH	OCT KWH	NOV KWH	DEC KWH	TOTAL KWH
150W HPS	190	79.71	67.39	67.96	59.06	55.17	50.54	53.67	58.78	63.31	72.27	75.74	81.41	**785.02**
ATB0	92	38.60	32.63	32.91	28.60	26.71	24.47	25.99	28.46	30.65	34.99	36.68	39.42	**380.11**
250W HPS	295	123.76	104.63	105.52	91.70	85.66	78.47	83.32	91.26	98.29	112.21	117.60	126.40	**1,218.84**
ATB2	143	59.99	50.72	51.15	44.45	41.52	38.04	40.39	44.24	47.65	54.39	57.01	61.27	**590.83**

Pilot Locations

The LED Street Lighting Pilot was conducted in the following communities in Missouri: Branson, Neosho, Ozark, Republic, and Webb City. Per the parameters of the pilot project, a two (2) block section of continuous roadway was chosen in each city. Empire personnel, in conjunction with guidance from city personnel, performed a field assessment for each location in order to determine a suitable street location to conduct the research.

Specific criteria used in determining street location included the class type for the street, pedestrian conflict, dimensions of the street and/or sidewalks, and the dimensions of surrounding buildings. The existing HPS light fixtures, mounting heights, and pole spacing were also determined during the field assessment. After performing the initial field assessment, a 2D layout was created for each location using AutoCAD. The AutoCAD layouts were input into Visual, a software program used to create exterior lighting layouts for roadways. The result was a lighting layout in 2D and 3D, which was used to evaluate whether or not the existing pole locations would meet RP8 new LED lighting standards. If it was determined that additional light poles were required, Visual was used to determine the specific pole locations. This is critical in designing a lighting layout that will meet RP8 Standards. Depending on the design, the pole locations can vary and still meet RP8 Standards.

For the Branson pilot location, the location of the new pole was chosen based on lighting calculations performed in Visual, while also keeping similar spacing between poles. Empire utilized an Extech light meter to verify the expected light level output in the foot candles at each location after the initial LED light fixture installation. Furthermore, a follow up measurement was taken at each location roughly halfway into the pilot project to verify if significant light output degradation had occurred for any of the installed LED light fixtures. It should be noted that Empire did not detect any significant change in light output for any of the newly installed LED fixtures. The remaining report provides further LED Street lighting scope details, installation costs, spare material costs and metering results of each pilot location.

Pilot Location: Branson – Roark Valley Rd from Forsythe Blvd to Truman Dr

The Road Class for this location was Major with low pedestrian conflict. The existing HPS street light had seven (7) 150W HPS cobra head fixtures installed on wood poles. ATB0 replacement LED light fixtures were installed on the first four (4) existing poles on Forsythe Blvd. ATB2 LED light fixtures, rather than ATB0 LED light fixture replacements, were installed on existing poles on the last three (3) lights before Truman Drive in order to meet RP8 lighting standards. A new ATB2 light fixture and a new 45' Class 4 wood pole 165' were installed to the right of the fourth ATB0 light fixture pass Forsythe Blvd. These were required to meet RP8 lighting standards. Tables 5 and 6 below contain values for the total installation cost (excluding metering) and spare material cost.

Table 5 – Branson Installation Costs

INSTALLATION TYPE	INSTALL COST	QUANTITY	TOTAL COST
ATB0 (EXISTING POLE)	$354.40	4	$1,417.60
ATB2 (EXISTING POLE)	$632.53	3	$1,897.59
ATB2 (NEW POLE)	$1,447.23	1	$1,447.23
TOTAL INSTALLATION COST			**$4,762.42**

Table 6 – Branson Spare Material Costs

SPARE TYPE	MATERIAL COST	QUANTITY	TOTAL COST
ATB0	$238.82	5	$1,194.10
ATB2	$470.01	3	$1,410.03
DTL PHOTOCONTROL	$19.74	4	$78.96
TOTAL SPARE MATERIAL COST			**$3,172.84**

It should be noted that an accident involving a non-Empire vehicle hit one of the ATB2 LED light fixture poles, which required a complete rebuild of that portion of the 3PH circuit. This accident triggered a

maintenance event, but the expenses pertaining to this accident are not attributed to the LED street lighting pilot. If the cost to replace the fixture, photocontrol, and street light cable is determined to be a component of the pilot, it is estimated to cost approximately $792.80.

A comparison of Metered LED Street Lighting kWh energy usage versus Projected (based on Table 4 above) kWh energy usage for the LED street lighting pilot circuit in Branson for 2015, 2016, and 2017 is shown in Tables 7, 8 and 9 below.

Table 7 – Branson Metered LED Street Lighting versus Projected LED Street Lighting kWh usage for 2015

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-15	394.36	396.13	1.77	0.45%
Feb-15	333.40	337.20	3.80	1.13%
Mar-15	336.24	342.22	5.98	1.75%
Apr-15	292.20	295.04	2.84	0.96%
May-15	272.92	277.26	4.34	1.57%
Jun-15	250.04	250.31	0.27	0.11%
Jul-15	265.52	265.23	-0.29	-0.11%
Aug-15	290.80	290.74	-0.06	-0.02%
Sep-15	313.20	310.27	-2.93	-0.94%
Oct-15	357.52	355.45	-2.07	-0.58%
Nov-15	374.76	374.99	0.23	0.06%
Dec-15	402.76	401.52	-1.24	-0.31%
TOTAL	**3,883.72**	**3,896.36**	**12.64**	**0.32%**

Table 8 – Branson Metered LED Street Lighting versus Projected LED Street Lighting kWh usage for 2016

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-16	394.36	394.74	0.38	0.10%
Feb-16	333.40	345.84	12.44	3.60%
Mar-16	336.24	337.46	1.22	0.36%
Apr-16	292.20	293.84	1.64	0.56%
May-16	272.92	275.02	2.10	0.76%
Jun-16	250.04	249.57	-0.47	-0.19%
Jul-16	265.52	265.10	-0.42	-0.16%
Aug-16	290.80	290.35	-0.45	-0.15%
Sep-16	313.20	311.55	-1.65	-0.53%
Oct-16	357.52	355.72	-1.80	-0.51%
Nov-16	374.76	374.39	-0.37	-0.10%
Dec-16	402.76	405.00	2.24	0.55%
TOTAL	**3,883.72**	**3,898.58**	**14.86**	**0.38%**

Table 9 – Branson Metered LED Street Lighting versus Projected LED Street Lighting kWh usage for 2017

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-17	394.36	397.10	2.74	0.69%
Feb-17	333.40	333.89	0.49	0.15%
Mar-17	336.24	340.05	3.81	1.12%
Apr-17	292.20	299.14	6.94	2.32%
May-17	272.92	277.08	4.16	1.50%
Jun-17	250.04	252.44	2.40	0.95%
Jul-17	265.52	265.89	0.37	0.14%
Aug-17	290.80	288.90	-1.90	-0.66%
Sep-17	313.20	318.15	4.95	1.56%
Oct-17	357.52	366.59	9.07	2.47%
Nov-17	374.76	388.19	13.43	3.46%
Dec-17	402.76	419.10	16.34	3.90%
TOTAL	**3,480.96**	**3,527.42**	**62.80**	**1.59%**

The average annual energy usage was calculated to be 0.76% higher than projected. Had the previously installed HPS lighting fixtures been setup to meet RP8 lighting standards, the projected average annual energy savings from switching to LED lighting fixtures, in the pilot location in Branson, would have been 50.76%.

Pilot Location Neosho – W Hickory St from S Jefferson St to S Washington St

The Road Class for this location was Collector with medium pedestrian conflict. The existing installation had ten (10) 150W HPS cobra head fixtures on steel poles. LED light fixture ATB0 replacements were used on all ten (10) HPS lighting fixtures. All existing poles were used for the ten (10) lights. Tables 10 and 11 below contain values for the total installation cost (excluding metering) and spare material cost.

Table 10 – Neosho Installation Costs

INSTALLATION TYPE	INSTALL COST	QUANTITY	TOTAL COST
ATB0 (EXISTING POLE)	$354.40	10	**$3,544.04**

Table 11 – Neosho Spare Material Costs

SPARE TYPE	MATERIAL COST	QUANTITY	TOTAL COST
ATB0	$238.82	2	$477.64
DTL PHOTOCONTROL	$19.74	6	$118.44
TOTAL SPARE MATERIAL COST			**$596.08**

A comparison of LED street lighting metered vs projected LED street lighting (based on Table 4 above) kWh energy usage for the LED pilot circuit in Neosho for 2015, 2016 and 2017 is shown in Tables 12, 13 and 14 below.

Table 12 – Neosho Metered LED Street Lighting versus Projected LED Street Lighting kWh for 2015

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-15	386.00	399.84	13.84	3.46%
Feb-15	326.30	341.02	14.72	4.32%
Mar-15	329.10	343.27	14.17	4.13%
Apr-15	286.00	296.83	10.83	3.65%
May-15	267.10	279.13	12.03	4.31%
Jun-15	244.70	250.23	5.53	2.21%
Jul-15	259.90	265.16	5.26	1.98%
Aug-15	284.60	291.74	7.14	2.45%
Sep-15	306.50	312.51	6.01	1.92%
Oct-15	349.90	358.32	8.42	2.35%
Nov-15	366.80	378.89	12.09	3.19%
Dec-15	394.20	406.69	12.49	3.07%
TOTAL	**3,801.10**	**3,923.63**	**122.53**	**3.12%**

Table 13 – Neosho Metered LED Street Lighting versus Projected LED Street Lighting kWh for 2016

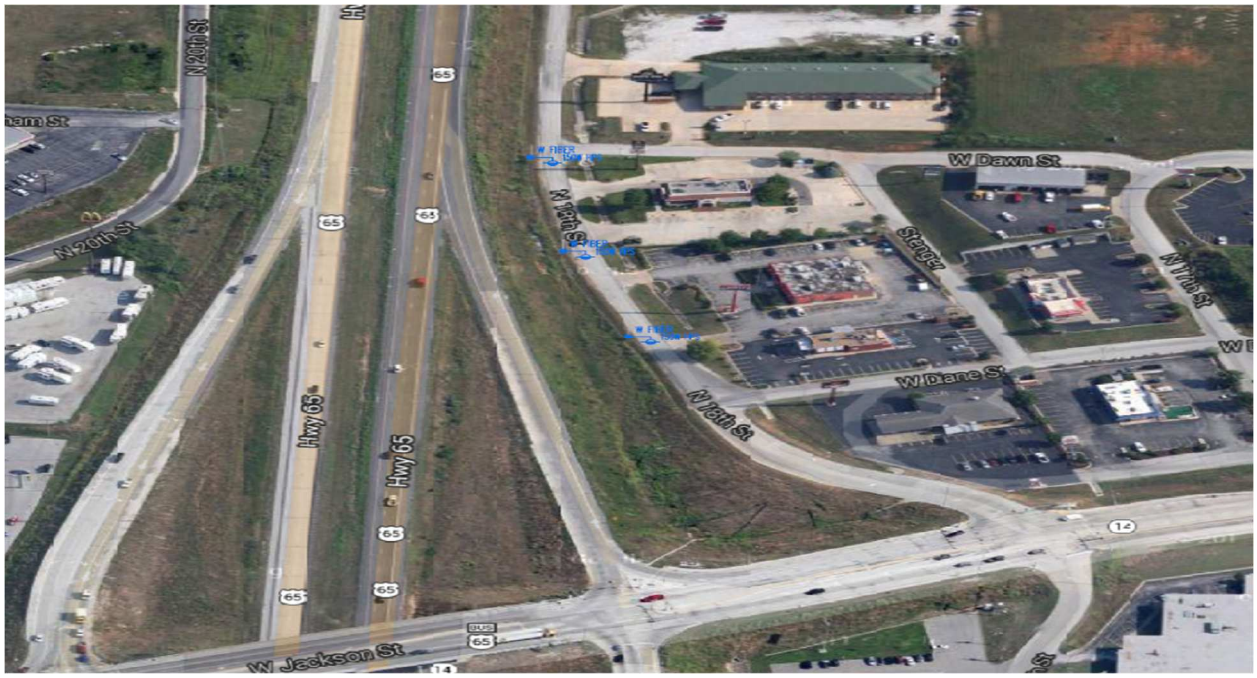
MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-16	386.00	400.7	14.70	3.67%
Feb-16	326.30	348.66	22.36	6.41%
Mar-16	329.10	340.44	11.34	3.33%
Apr-16	286.00	295.71	9.71	3.28%
May-16	267.10	276.12	9.02	3.27%
Jun-16	244.70	248.69	3.99	1.60%
Jul-16	259.90	265.47	5.57	2.10%
Aug-16	284.60	290.79	6.19	2.13%
Sep-16	306.50	312.99	6.49	2.07%
Oct-16	349.90	358.34	8.44	2.36%
Nov-16	366.80	376.49	9.69	2.57%
Dec-16	394.20	409.47	15.27	3.73%
TOTAL	**3,801.10**	**3,923.87**	**122.77**	**3.13%**

Table 14 – Neosho Metered LED Street Lighting versus Projected LED Street Lighting kWh for 2017

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-17	386.00	400.77	14.77	3.69%
Feb-17	326.30	336.36	10.06	2.99%
Mar-17	329.10	342.91	13.81	4.03%
Apr-17	286.00	301.84	15.84	5.25%
May-17	267.10	278.49	11.39	4.09%
Jun-17	244.70	252.08	7.38	2.93%
Jul-17	259.90	264.67	4.77	1.80%
Aug-17	284.60	293.27	8.67	2.96%
Sep-17	306.50	313.38	6.88	2.20%
Oct-17	349.90	359.16	9.26	2.58%
Nov-17	366.80	378.69	11.89	3.14%
Dec-17	394.20	409.14	14.94	3.65%
TOTAL	**3,801.10**	**3,930.76**	**129.66**	**3.30%**

The average annual energy usage was calculated to be 3.18% higher than projected. By replacing the existing 150W HPS fixtures with equivalent LED light fixtures, the projected average annual energy savings is calculated to be 49.99%.

Pilot Location: Ozark – N 18th St from W Dawn St to W Diane St



The Road Class for this location was Collector with low pedestrian conflict. The existing installation had three (3) 150W HPS cobra head fixtures on fiberglass poles. ATB0 LED Street Light Fixtures replacements were installed on existing poles for all three (3) lights. Tables 15 and 16 below contain values for the total installation cost (excluding metering) and spare material cost.

Table 15 – Ozark Installation Costs

INSTALLATION TYPE	INSTALL COST	QUANTITY	TOTAL COST
ATB0 (EXISTING POLE)	$354.40	3	**$1,063.21**

Table 16 – Ozark Spare Material Costs

SPARE TYPE	MATERIAL COST	QUANTITY	TOTAL COST
ATB0	$238.82	3	$716.46
DTL PHOTOCONTROL	$19.74	3	$59.22
RIPLEY PHOTOCONTROL	$29.27	3	$87.81
TOTAL SPARE MATERIAL COST			**$863.49**

A comparison of Metered LED Street Lighting vs Projected LED Street Lighting (based on Table 4 above) kWh energy usage for the LED pilot circuit in Ozark for 2015, 2016 and 2017 is shown in Tables 17, 18 and 19 below.

Table 17 – Ozark Metered LED Street Lighting versus Projected LED Street Lighting kWh for 2015

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-15	115.80	122.04	6.24	5.11%
Feb-15	97.89	104.05	6.16	5.92%
Mar-15	98.73	104.98	6.25	5.95%
Apr-15	85.80	90.55	4.75	5.25%
May-15	80.13	85.45	5.32	6.23%
Jun-15	73.41	76.93	3.52	4.58%
Jul-15	77.97	81.71	3.74	4.58%
Aug-15	85.38	89.11	3.73	4.19%
Sep-15	91.95	95.32	3.37	3.54%
Oct-15	104.97	109.21	4.24	3.88%
Nov-15	110.04	115.13	5.09	4.42%
Dec-15	118.26	123.71	5.45	4.41%
TOTAL	**1,140.33**	**1,198.19**	**57.86**	**4.83%**

Table 18 – Ozark Metered LED Street Lighting versus Projected LED Street Lighting kWh for 2016

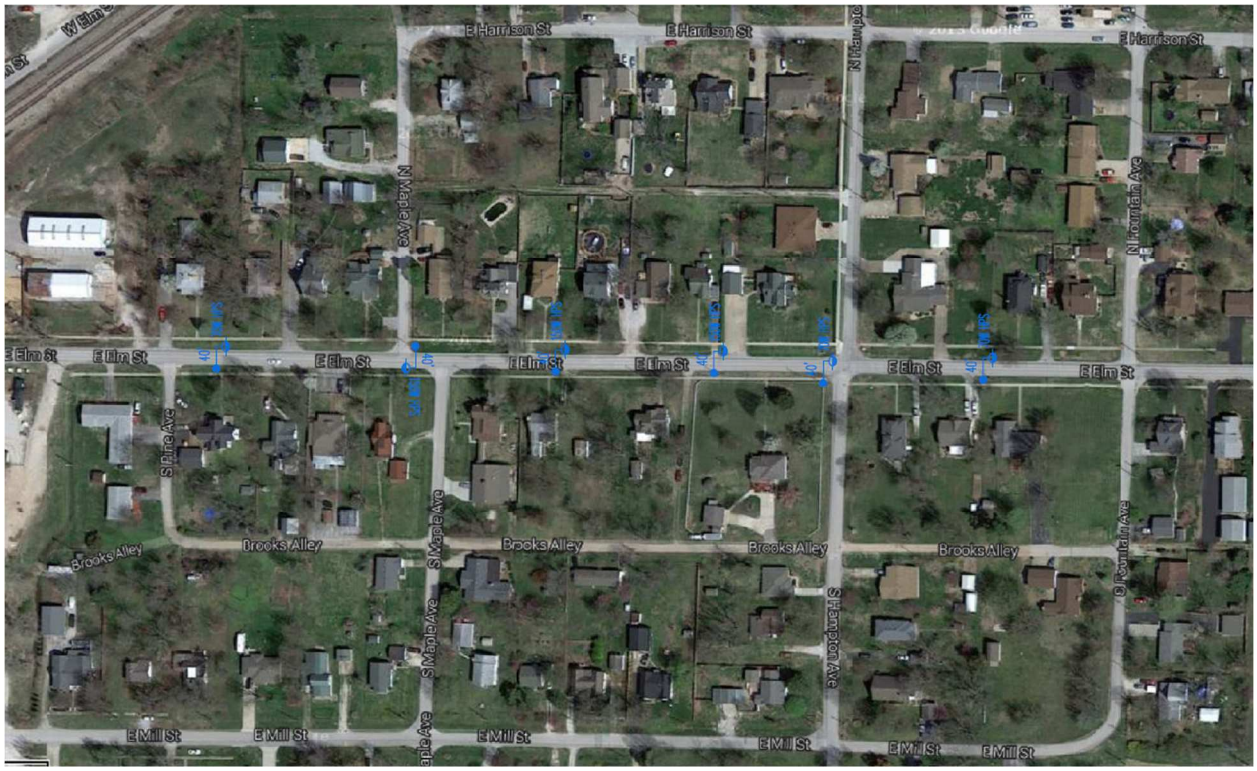
MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-16	115.80	122.11	6.31	5.17%
Feb-16	97.89	106.48	8.59	8.07%
Mar-16	98.73	104.01	5.28	5.08%
Apr-16	85.80	90.05	4.25	4.72%
May-16	80.13	84.56	4.43	5.24%
Jun-16	73.41	76.44	3.03	3.96%
Jul-16	77.97	81.06	3.09	3.81%
Aug-16	85.38	88.96	3.58	4.02%
Sep-16	91.95	95.35	3.40	3.57%
Oct-16	104.97	109.19	4.22	3.86%
Nov-16	110.04	115.15	5.11	4.44%
Dec-16	118.26	124.79	6.53	5.23%
TOTAL	**1,140.33**	**1,198.15**	**57.82**	**4.83%**

Table 19 – Ozark LED Street Lighting Metered vs Projected LED Street Lighting kWh for 2017

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-17	115.80	122.46	6.66	5.44%
Feb-17	97.89	102.68	4.79	4.66%
Mar-17	98.73	104.81	6.08	5.80%
Apr-17	85.80	91.8	6.00	6.54%
May-17	80.13	84.88	4.75	5.60%
Jun-17	73.41	77.12	3.71	4.81%
Jul-17	77.97	79.21	1.24	1.57%
Aug-17	85.38	88.82	3.44	3.87%
Sep-17	91.95	94.53	2.58	2.73%
Oct-17	104.97	108.46	3.49	3.22%
Nov-17	110.04	114.42	4.38	3.83%
Dec-17	118.26	123.79	5.53	4.47%
TOTAL	**1,022.07**	**1,069.19**	**47.12**	**4.41%**

The average annual energy usage was calculated to be 4.69% higher than projected. By replacing the existing 150W HPS light fixtures with equivalent LED light fixtures, the projected average annual energy savings is calculated to be 49.34%.

Pilot Location: Republic – E Elm St from S Pine Ave to S Fountain Ave



The Road Class for this location was Local with low pedestrian conflict. The existing HPS installation had six (6) 70W open bottom fixtures on fiberglass poles. Installed ATB0 LED light fixture replacements on existing poles for all six (6) lights. Tables 20 and 21 below contain values for the total installation cost (excluding metering) and spare material cost.

Table 20 – Republic Installation Costs

INSTALLATION TYPE	INSTALL COST	QUANTITY	TOTAL COST
ATB0 (EXISTING POLE)	$354.40	6	**$2,126.42**

Table 21 – Republic Spare Material Costs

SPARE TYPE	MATERIAL COST	QUANTITY	TOTAL COST
ATB0	$238.82	2	$477.64
DTL PHOTOCONTROL	$19.74	5	$98.70
RIPLEY PHOTOCONTROL	$29.27	2	$58.54
TOTAL SPARE MATERIAL COST			**$634.88**

A comparison of Metered LED Street Lighting vs Projected LED Street Lighting (based on Table 4 above) kWh energy usage for the LED pilot circuit in Republic for 2015, 2016 and 2017 is shown in Tables 22, 23 and 24 below.

Table 22 – Republic Metered LED Street Lighting versus Projected LED Street Lighting kWh for 2015

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-15	231.60	245.52	13.92	5.67%
Feb-15	195.78	208.93	13.15	6.29%
Mar-15	197.46	210.75	13.29	6.31%
Apr-15	171.60	181.77	10.17	5.59%
May-15	160.26	171.11	10.85	6.34%
Jun-15	146.82	153.92	7.10	4.61%
Jul-15	155.94	163.48	7.54	4.61%
Aug-15	170.76	179.38	8.62	4.81%
Sep-15	183.90	191.56	7.66	4.00%
Oct-15	209.94	219.84	9.90	4.50%
Nov-15	220.08	232.22	12.14	5.23%
Dec-15	236.52	249.5	12.98	5.20%
TOTAL	**2,280.66**	**2,407.98**	**127.32**	**5.29%**

Table 23 – Republic Metered LED Street Lighting versus Projected LED Street Lighting kWh for 2016

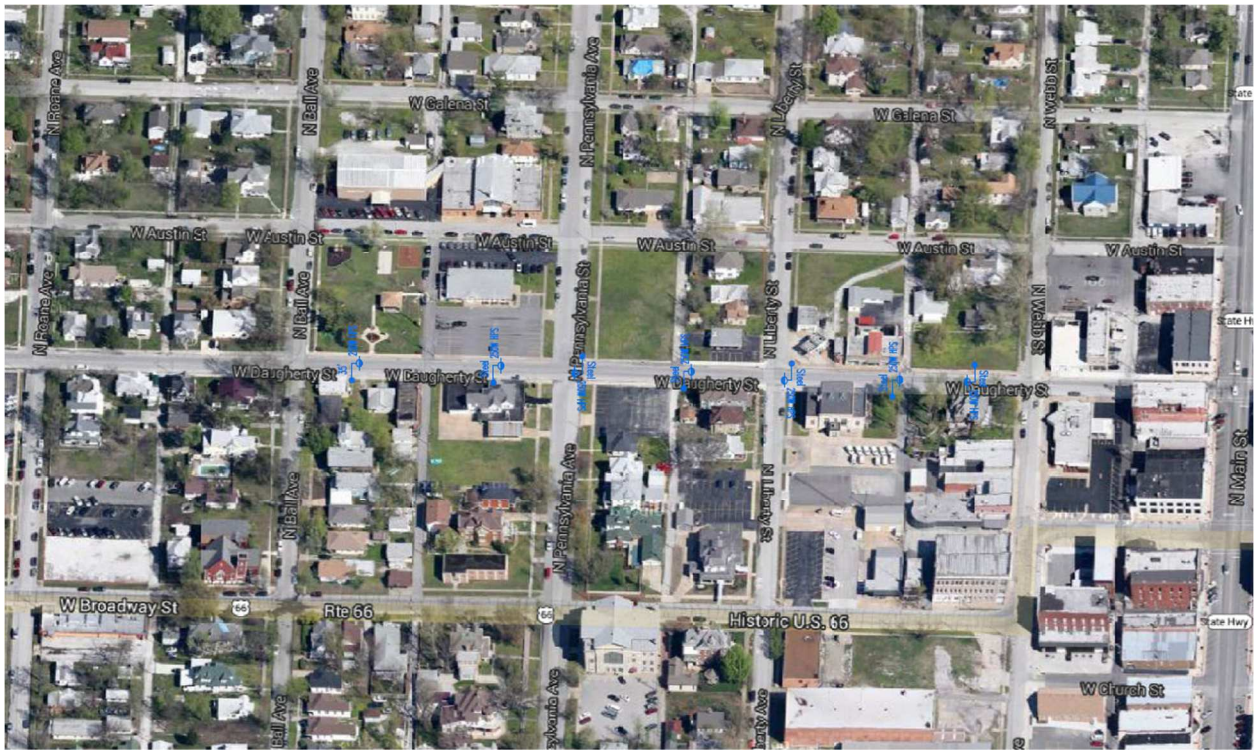
MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-16	231.60	245.53	13.93	5.67%
Feb-16	195.78	214.29	18.51	8.64%
Mar-16	197.46	209.06	11.60	5.55%
Apr-16	171.60	184.66	13.06	7.07%
May-16	160.26	170.08	9.82	5.77%
Jun-16	146.82	153.34	6.52	4.25%
Jul-16	155.94	163.21	7.27	4.45%
Aug-16	170.76	178.8	8.04	4.50%
Sep-16	183.90	191.92	8.02	4.18%
Oct-16	209.94	219.56	9.62	4.38%
Nov-16	220.08	231.17	11.09	4.80%
Dec-16	236.52	251.08	14.56	5.80%
TOTAL	**2,280.66**	**2,412.70**	**132.04**	**5.47%**

Table 24 – Republic Metered LED Street Lighting vs Projected LED Street Lighting kWh for 2017

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-17	231.60	246.23	14.63	5.94%
Feb-17	195.78	206.32	10.54	5.11%
Mar-17	197.46	210.61	13.15	6.24%
Apr-17	171.60	184.66	13.06	7.07%
May-17	160.26	169.45	9.19	5.42%
Jun-17	146.82	154.99	8.17	5.27%
Jul-17	155.94	161.61	5.67	3.51%
Aug-17	170.76	202.92	32.16	15.85%
Sep-17	183.90	191.28	7.38	3.86%
Oct-17	209.94	219.23	9.29	4.24%
Nov-17	220.08	230.84	10.76	4.66%
Dec-17	236.52	229.63	-6.89	-3.00%
TOTAL	**2,280.66**	**2,407.77**	**127.11**	**5.28%**

The average annual energy usage was calculated to be 5.35% higher than projected. By replacing the 70W HPS open bottom fixtures on fiberglass poles with ATB0s LED light fixtures, the projected average annual energy savings is calculated to be 48.85%.

Pilot Location: Webb City – W Daugherty St from N Ball Ave to N Main St



The Road Class for this location was Local with low pedestrian conflict. The existing HPS light fixture installation had six (6) 250W cobra head fixtures on steel poles and one (1) 250W cobra head fixture on a wood pole. During the site evaluation, Webb City line operations personnel made a determination to change the scope to only include the six (6) 250W HPS cobra head fixtures on steel poles and installed ATB2 LED replacement light fixtures on existing poles for six (6) lights. Tables 25 and 26 below contain values for the total installation cost (excluding metering) and spare material cost.

Table 25 – Webb City Installation Costs

INSTALLATION TYPE	INSTALL COST	QUANTITY	TOTAL COST
ATB2 (EXISTING POLE)	$632.53	6	**$3,795.15**

Table 26 – Webb City Spare Material Costs

SPARE TYPE	MATERIAL COST	QUANTITY	TOTAL COST
ATB2	$470.01	4	$1,880.04
DTL PHOTOCONTROL	$19.74	6	$118.44
RIPLEY PHOTOCONTROL	$29.27	3	$87.81
TOTAL SPARE MATERIAL COST			**$2,086.29**

A comparison of Metered LED Street Lighting vs Projected LED Street Lighting (based on Table 4 above) kWh energy usage for the LED pilot circuit in Webb City for 2015, 2016 and 2017 is shown in Tables 27, 28 and 29 below.

Table 27 – Webb City Metered LED Street Lighting versus Projected LED Street Lighting kWh for 2015

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-15	359.94	366.29	6.35	1.76%
Feb-15	304.32	312.2	7.88	2.59%
Mar-15	306.90	313.68	6.78	2.21%
Apr-15	266.70	272.29	5.59	2.10%
May-15	249.12	254.7	5.58	2.24%
Jun-15	228.24	228.41	0.17	0.07%
Jul-15	242.34	241.98	-0.36	-0.15%
Aug-15	265.44	266.45	1.01	0.38%
Sep-15	285.90	285.78	-0.12	-0.04%
Oct-15	326.34	328.69	2.35	0.72%
Nov-15	342.06	347.33	5.27	1.54%
Dec-15	367.62	372.79	5.17	1.41%
TOTAL	**3,544.92**	**3,590.59**	**45.67**	**1.27%**

Table 28 – Webb City Metered LED Street Lighting versus Projected LED Street Lighting kWh for 2016

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-16	359.94	367	7.06	1.92%
Feb-16	304.32	319.23	14.91	4.67%
Mar-16	306.90	311.39	4.49	1.44%
Apr-16	266.70	270.03	3.33	1.23%
May-16	249.12	252.69	3.57	1.41%
Jun-16	228.24	228.06	-0.18	-0.08%
Jul-16	242.34	241.56	-0.78	-0.32%
Aug-16	265.44	266.36	0.92	0.35%
Sep-16	285.90	286.22	0.32	0.11%
Oct-16	326.34	328.9	2.56	0.78%
Nov-16	342.06	345.25	3.19	0.92%
Dec-16	367.62	375.39	7.77	2.07%
TOTAL	**3,544.92**	**3,592.08**	**47.16**	**1.31%**

Table 29 – Webb City Metered LED Street Lighting versus Projected LED Street Lighting kWh for 2017

MONTH	PROJECTED KWH	ACTUAL KWH	KWH ERROR	%ERROR
Jan-17	359.94	368.22	8.28	2.25%
Feb-17	304.32	308.43	4.11	1.33%
Mar-17	306.90	313.45	6.55	2.09%
Apr-17	266.70	275.52	8.82	3.20%
May-17	249.12	253.65	4.53	1.79%
Jun-17	228.24	230.47	2.23	0.97%
Jul-17	242.34	241.98	-0.36	-0.15%
Aug-17	265.44	268.48	3.04	1.13%
Sep-17	285.90	287.17	1.27	0.44%
Oct-17	326.34	329.7	3.36	1.02%
Nov-17	342.06	347.75	5.69	1.64%
Dec-17	367.62	375.47	7.85	2.09%
TOTAL	**3,544.92**	**3,600.29**	**55.37**	**1.54%**

The average annual energy usage was calculated to be 1.37% higher than projected. By replacing the existing 250W HPS light fixtures with its equivalent LED light fixtures, the projected average annual energy savings is calculated to be 50.85%.

Pilot Results Summary

From a high level evaluation of the data, it appears the average annual energy usage (kWh) for all five (5) pilot locations was approximately 3.07% higher than projected. The information used to project the kWh usage is based upon sunrise and sunset hours provided by the US Naval Observatory. This data does not take into consideration cloud coverage or stormy weather. This contributed to a variance in the projected kWh and the actual kWh used at each location. Our test sample consisted of thirty-three lights spread over five different locations.

If all five (5) pilot locations had been initially installed to the RP8 lighting standards, with HPS fixtures, then switching to the LED light fixtures would have provided projected average annual energy usage savings of 49.96%. During the time frame of the LED street lighting pilot, no LED light fixtures or long life photocontrols failed, except for the ATB2 light fixture. As previously mentioned in the report, this failure was the result of an accident involving a non-Empire vehicle hitting a pole.

The total cost (excluding metering costs) for the LED Street Light Pilot project is broken out below:

●Installation cost	$15,291.24
●Maintenance cost	$ 792.80
●Spare material cost	$ 7,353.58
Total cost	$23,437.62

Conclusion

A major outcome of the LED Street Light Pilot was the exposure of energy-efficient LED street lights to community leaders and residents. The participating communities were pleased with the performance of the LED streetlights and gained valuable knowledge regarding the benefits of switching to LED streetlights. The benefits included, but were not limited to, twenty-year life cycles, high-efficiency light fixtures, the ability to operate in very low temperatures, and instant on/off switches. The communities preferred the LED fixtures over the HPS fixtures and confirmed that the LED lights provided better uniformity and quality of light on roadway surfaces while limiting glare and the unintended spill of light. These benefits provided comfort and safety to motorists in low natural light driving conditions.

Another important factor that developed during the LED Street Light pilot was the maintenance of the current Series Street Lighting systems. With the exception of Joplin, Missouri, Empire has systematically replaced the Series Street Lighting systems with HPS systems within its service territory. Empire is now experiencing a critical issue with obtaining these maintenance parts as manufacturers no longer produce these parts. Empire is hopeful that the LED Street Light tariff can be developed soon so that the obsolete Series Street Lighting system can be renovated with LED Streetlights.

The LED Streetlights installed demonstrated lower energy usage compared to the conventional HPS streetlights. Though there were variances in the predicted kWh usage compared to the actual kWh usage, we feel this was due to the low sample size spread out over five different locations.

Empire plans to push forward in the development of a LED Street Light tariff and will continue to encourage community leaders to convert to the energy-efficient LED Street Light system.