

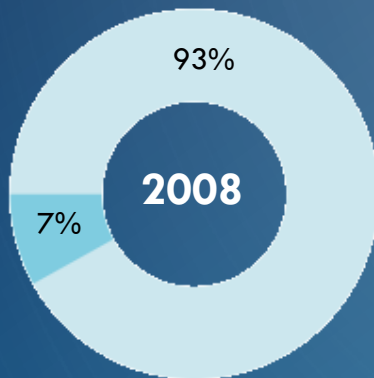
CITY OF FRISCO LED LIGHTING STUDY

BRIAN MOEN, PE, CITY OF FRISCO

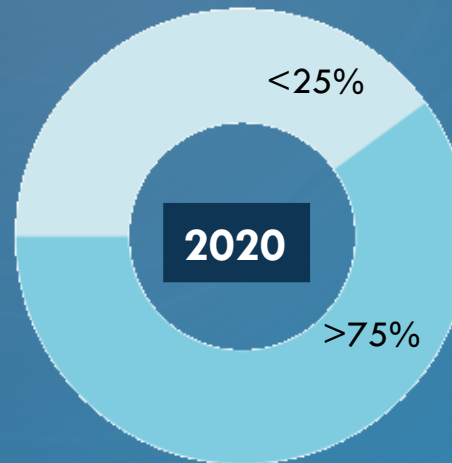
DHARMESH SHAH, PE, PTOE, LEE ENGINEERING



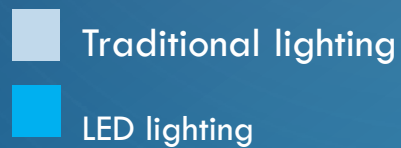
THE LED REVOLUTION



World market



World market



*Market estimate based on internal Philips study

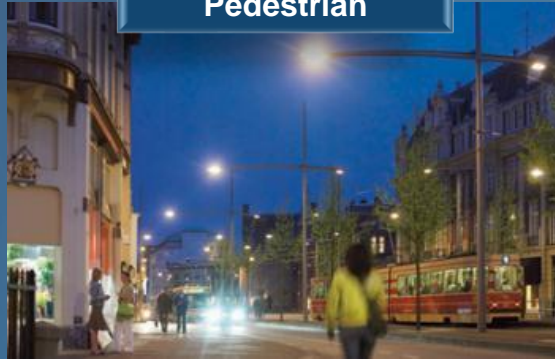


THE LED REVOLUTION

Roadway



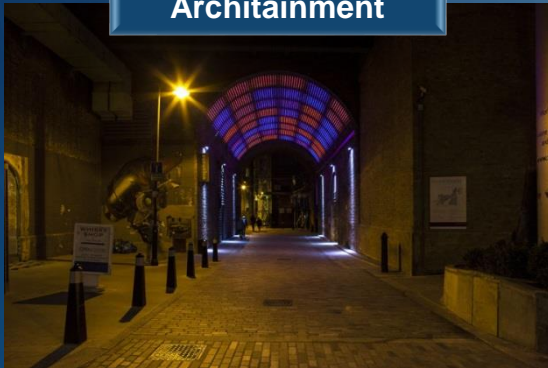
Pedestrian



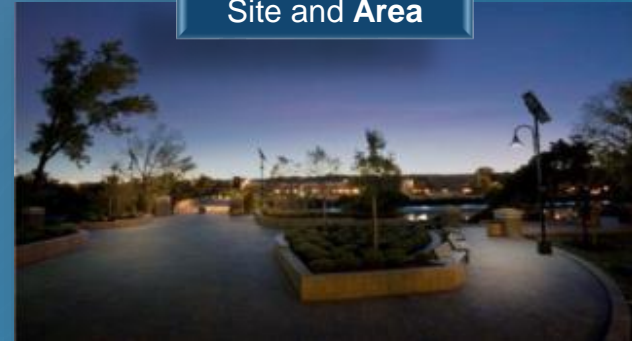
Tunnel



Architainment



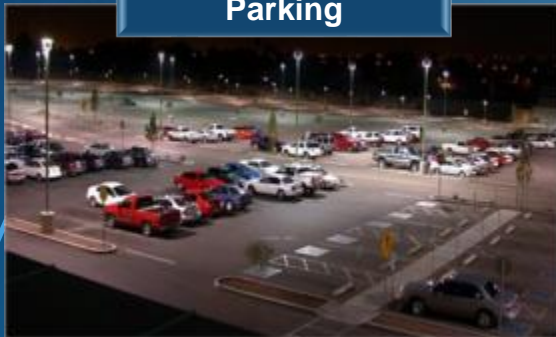
Site and Area



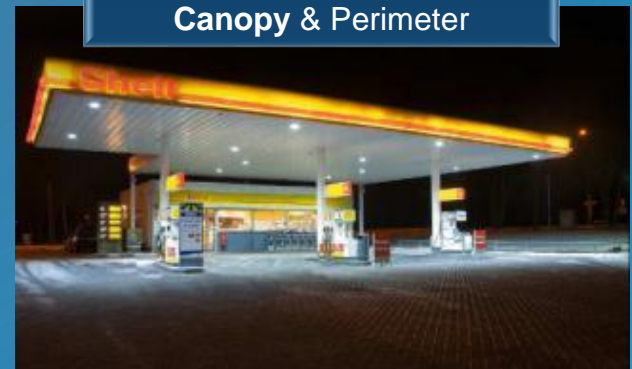
Parking Garage



Parking



Canopy & Perimeter

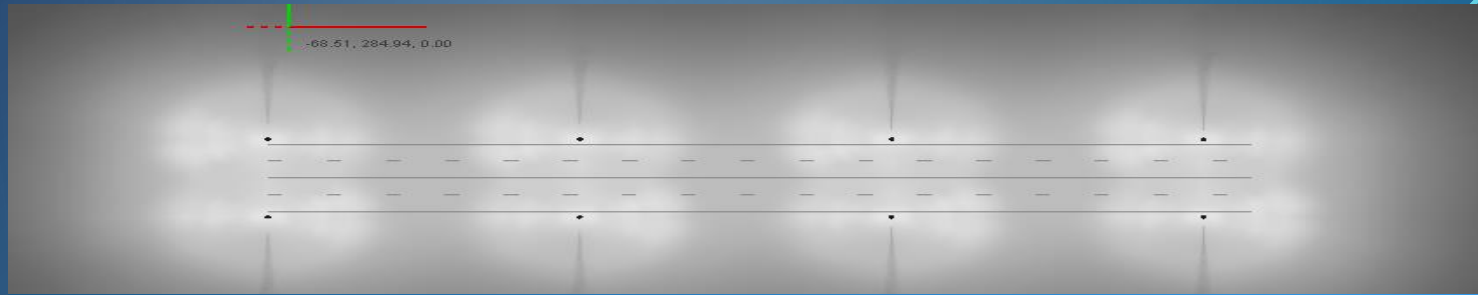


MAIN DIFFERENCE

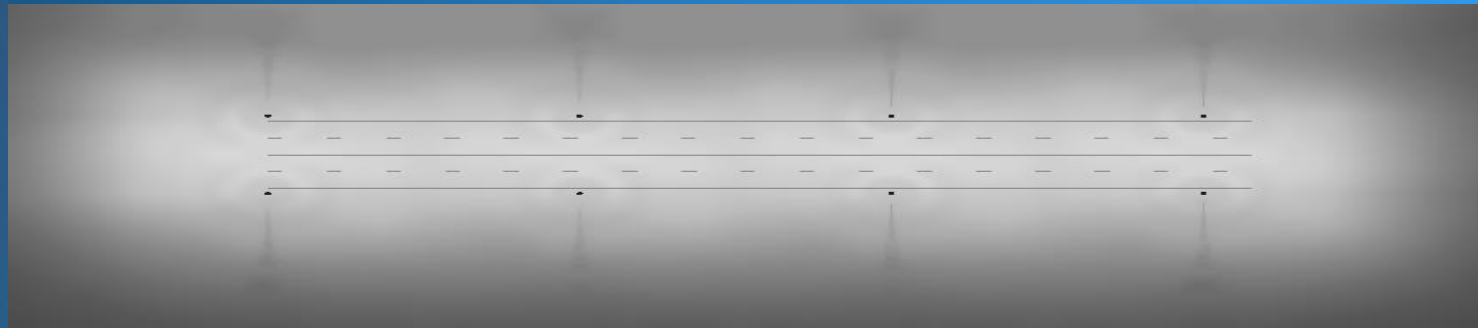
1. Lower Life Cycle Cost
2. Better Color and Visibility
3. Better Uniformity
4. Better Controls
5. Environmentally Friendly

LOWER LIFE CYCLE COST: BETTER OPTICS EQUALS LOWER WATTAGE

175W MH



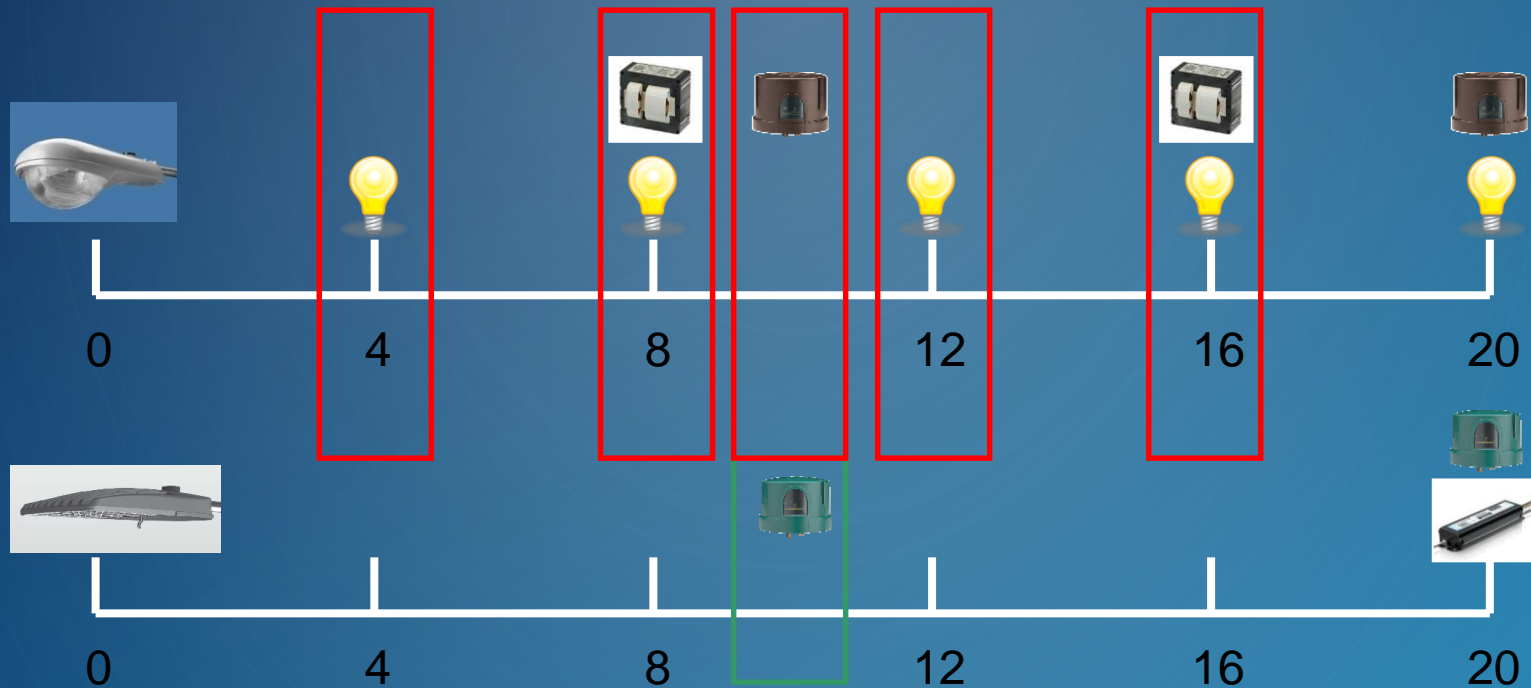
110W LED



4 Lane, 23'MH, 6' Overhang		
Luminaire Performance	175W MH Teardrop	110W LED Teardrop
Pole Spacing	127	127
Average Footcandles	1.0	1.1
Avg/Min	2.0	1.4
Power (Watts)	195	110
Energy Savings	Baseline	56%



LOWER LIFE CYCLE COST FEWER VISITS TO LUMINAIRE



80% Less Maintenance

This schedule represents the average time to replace key components of both an HID cobrahead and an LED luminaire.



HID ballast: every 8 years



HID lamp: every 4 years



Photocontrol: every 10 years



LED driver: every 20 years



PCSS control every 10 years

BETTER COLOR AND VISION: CORRELATED COLOR TEMPERATURE

- How well a light source renders colors.
- Color Rendering Index - Scale of 0-100.



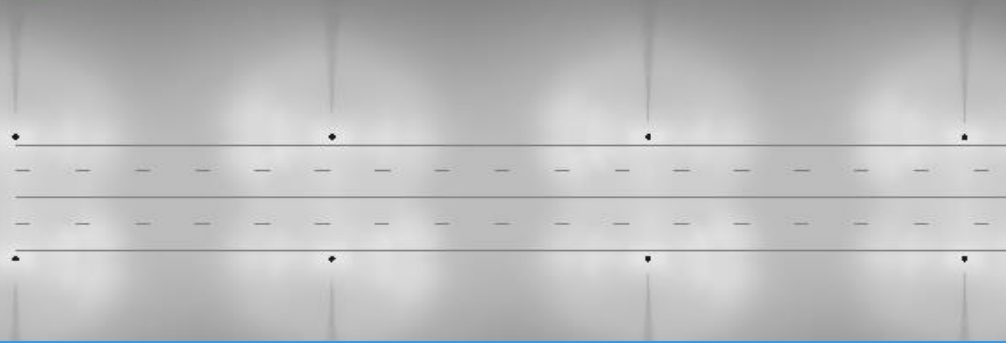
The **lower** the color temperature, the **warmer** the appearance of the light.



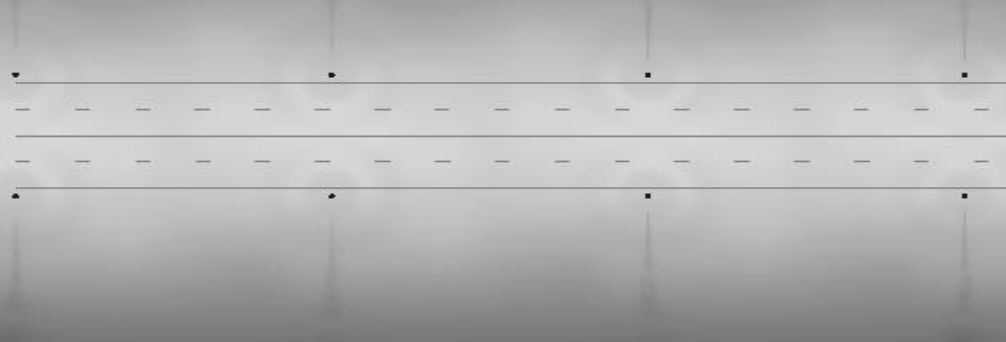
The **higher** the color temperature, the **cooler** the appearance of the light.

Better Uniformity: Streets and Roadways

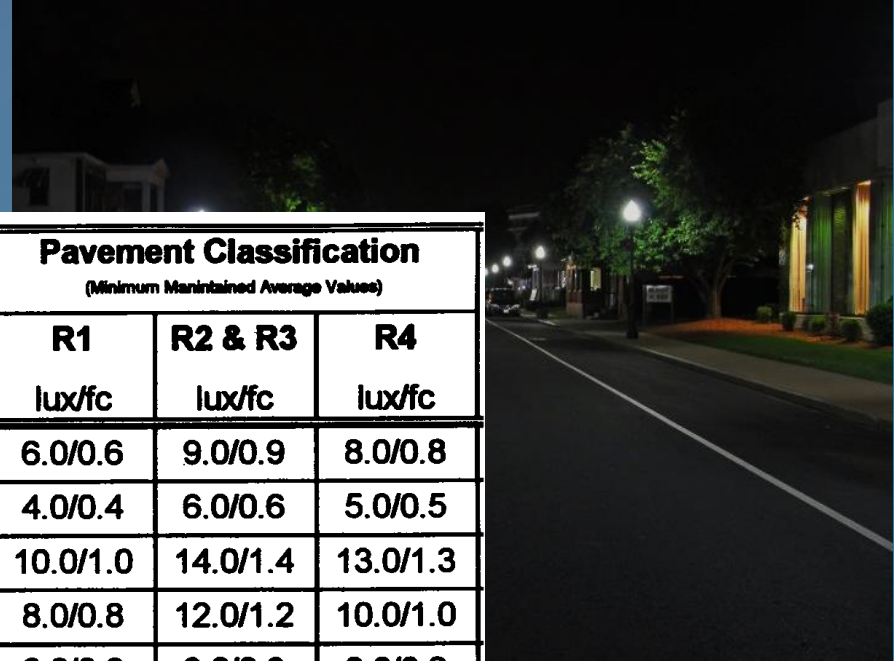
HID Application



LED Application

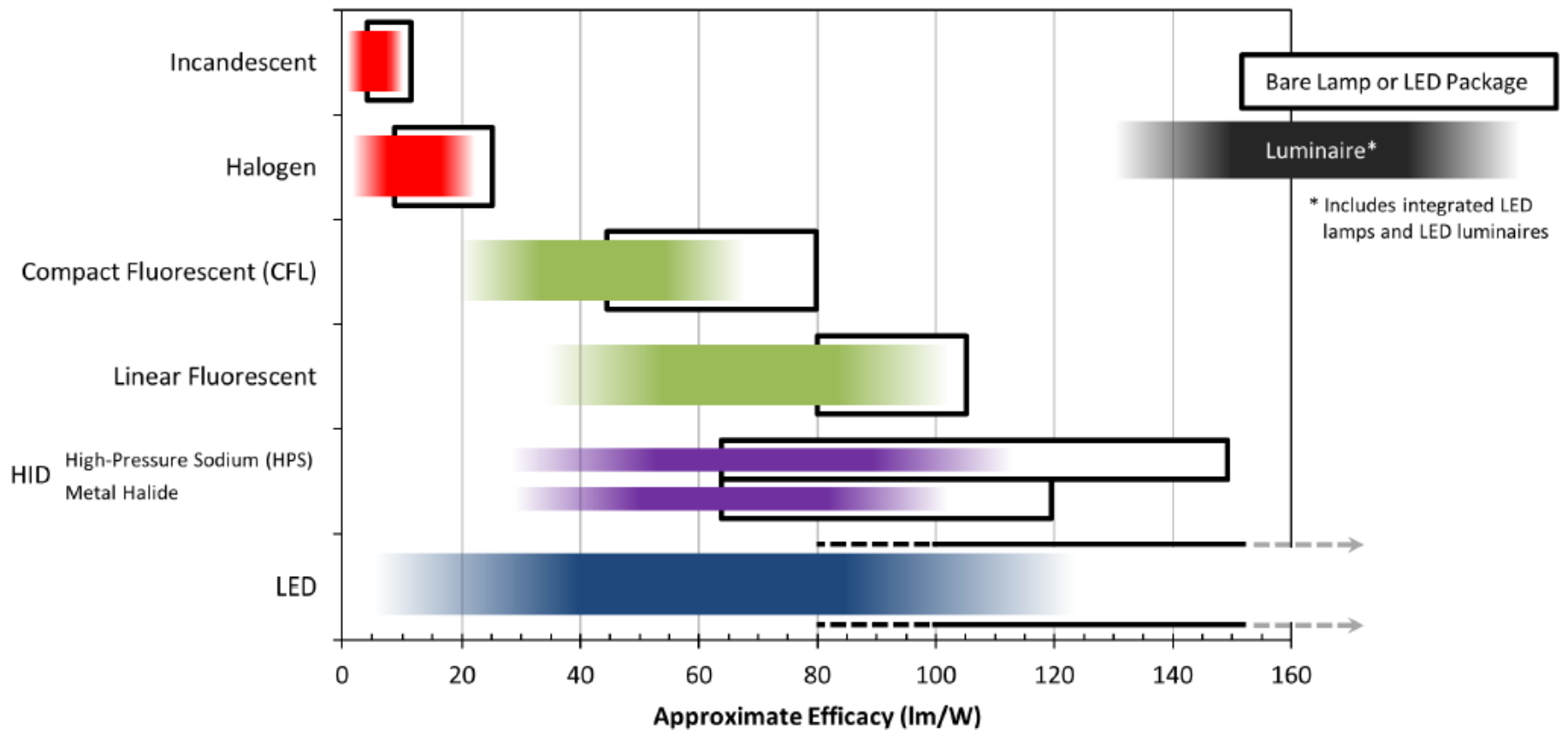


BETTER CONTROLS: ADAPTIVE LIGHTING



Road and Pedestrian Conflict Area		Pavement Classification (Minimum Maintained Average Values)		
Road	Pedestrian Conflict Area	R1 lux/ftc	R2 & R3 lux/ftc	R4 lux/ftc
Freeway Class A		6.0/0.6	9.0/0.9	8.0/0.8
Freeway Class B		4.0/0.4	6.0/0.6	5.0/0.5
Expressway	High	10.0/1.0	14.0/1.4	13.0/1.3
	Medium	8.0/0.8	12.0/1.2	10.0/1.0
	Low	6.0/0.6	9.0/0.9	8.0/0.8
Major	High	12.0/1.2	17.0/1.7	15.0/1.5
	Medium	9.0/0.9	13.0/1.3	11.0/1.1
	Low	6.0/0.6	9.0/0.9	8.0/0.8
Collector	High	8.0/0.8	12.0/1.2	10.0/1.0
	Medium	6.0/0.6	9.0/0.9	8.0/0.8
	Low	4.0/0.4	6.0/0.6	5.0/0.5
Local	High	6.0/0.6	9.0/0.9	8.0/0.8
	Medium	5.0/0.5	7.0/0.7	6.0/0.6
	Low	3.0/0.3	4.0/0.4	4.0/0.4

SYSTEM EFFICACY COMPARISON



Of the light source technologies listed, only LED is expected to make substantial increases in efficacy in the near future.

CASE STUDY

CITY OF FRISCO LED LIGHTING STUDY



LEE ENGINEERING

STUDY APPROACH

- Existing Lighting
- Request for Information
- Short List
- Pilot Study - Field Measurements
- Evaluation & Payback Analysis



EXISTING LIGHTING

- 480V
- 30' MH
- 4' Arm



Arterial – 250W MH

5300 Plus Lights



Downtown – 150W MH

OTHER TECHNOLOGIES

- LED



- Energy Savings

- Bold claims?

- Cost

- Worth it?

- New or Retrofit?

- Induction



REQUEST FOR INFORMATION

- Application Based
- Buy America Mandate
- Shop Drawings
- Installation & Maintenance Requirements
- List Price
- Warranty – Min 5 Years
- Retrofit Kit
- Lighting Control Systems

REQUEST FOR INFORMATION

- 15 Vendors Responded

	Induction	LED
Vendors	4	13
Cost	\$240 - \$600	\$330 - \$1200
Warranty	5 – 10 years	5 – 10 Years
Retrofit	Available	Available
Life	50K – 100K Hours	50K – 100K Hours
Input Watt	120W – 177W	88W – 177W
Technology	Proven – No R&D	Rapidly Improving

- Retrofit – Reduced warranty, little cost advantage

REQUEST FOR INFORMATION

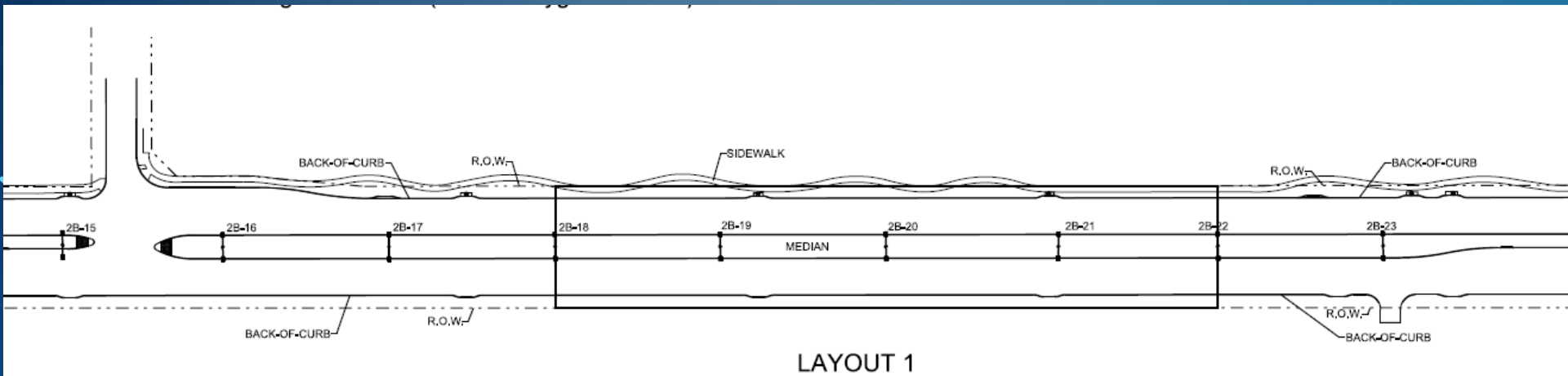
- Vendor Presentation
 - Induction - 2
 - LED – 6
- Induction - Not Considered Further
 - No more technological improvement
 - Market trend
 - Little cost advantage

REQUEST FOR INFORMATION

- Three LED Chip Manufacturers
- LED Driver (Power Supply)
- Surge Protector
- Warranty – Entire fixture?
- Hard to Obtain Cost Information

PILOT STUDY

- Application Based



- LED – Five Vendors Selected for Pilot Study
- Four Vendors Provided Fixtures

PILOT STUDY

Photometric Analysis Criteria

Classification of Area	Major
Road Surface Classification	R1 – Portland cement concrete
Pedestrian Conflict Area	Low to Medium
Minimum Maint. Average Illuminance	0.6 to 0.9 fc
Uniformity Ratio (avg/min)	3.0
Total Light Loss Factor (LLF)	0.92
Luminaire Mounting Height	30 feet
Arm Length	4 feet
Electrical Service	480V

PILOT STUDY



PILOT STUDY

- Fixture Assembly
 - 10-15 Minutes
- Fixture Installation
 - 12 to 20 Minutes
- Ease of Installation
 - Wiring
 - Weight

Overall assembly and Installation
Time Similar – after few installs



PILOT STUDY



PILOT STUDY



Vendor 1



Vendor 3



Vendor 2



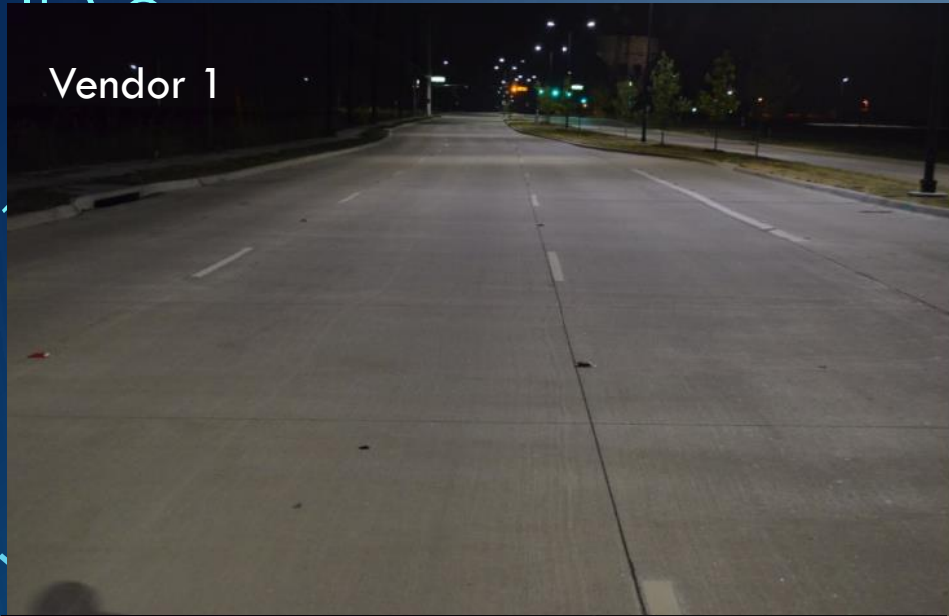
Vendor 4

PILOT STUDY

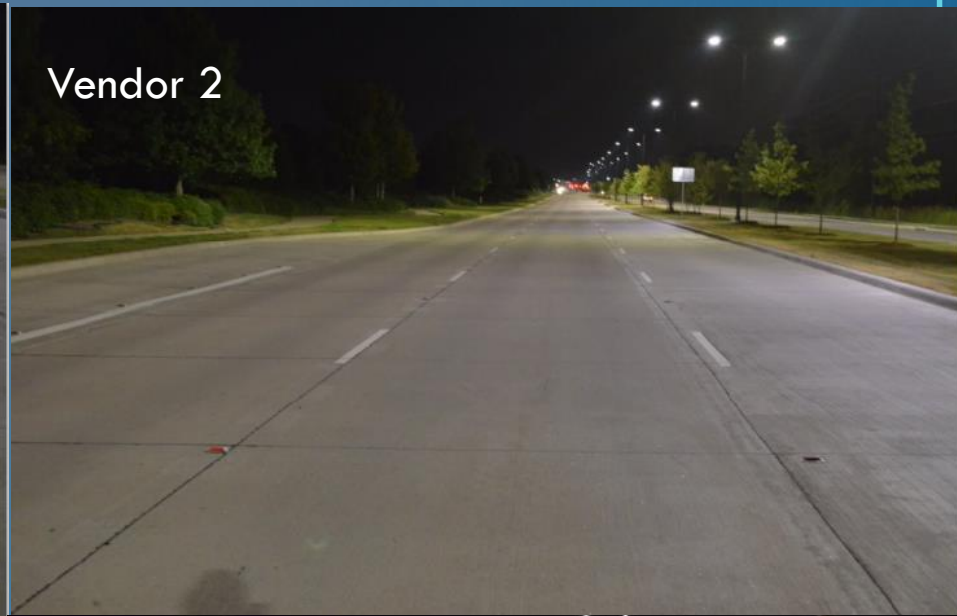
- Photometric Analysis V/S Field Measurement
 - Field Measured fc values – Similar to Photometric Analysis Provided by Vendors
- Visual Observation - Better than Existing MH
 - Hot spots
 - Sidewalk
- Wattage Measurement

PILOT STUDY

Vendor 1



Vendor 2



Vendor 3



Vendor 4



PILOT STUDY

Existing MH

Median



Min	Max	Avg	Uniformity
0.16	2.68	0.71	4.45

Curb



Curb

0.36	0.43	0.52	0.97	1.31	1.97	2.68	2.43	1.53	1.03	0.61	0.39	0.34
0.37	0.32	0.49	0.74	1.22	1.68	2.17	1.92	1.37	0.91	0.57	0.37	0.33
0.42	0.41	0.53	0.82	1.14	1.31	1.56	1.49	1.25	0.87	0.57	0.32	0.37
0.46	0.43	0.5	0.88	1.05	1.03	1.11	1.16	1.11	0.83	0.49	0.37	0.44
0.47	0.46	0.5	0.83	0.88	0.76	0.79	0.8	0.87	0.83	0.53	0.42	0.46
0.47	0.39	0.58	0.69	0.63	0.56	0.57	0.59	0.72	0.56	0.42	0.42	0.44
0.5	0.46	0.58	0.72	0.54	0.45	0.28	0.51	0.49	0.6	0.63	0.45	0.41
0.34	0.26	0.27	0.65	0.31	0.27	0.26	0.27	0.16	0.34	0.19	0.3	0.17

3'

21'

36'

46'

FRISCO

LEE ENGINEERING

PILOT STUDY

Vendor 1 – 190W

Median



Min	Max	Avg	Uniformity
0.14	2.13	.82	5.88

0.57	0.58	0.66	0.9	1.48	2.04	1.95	2.13	1.65	0.96	0.75	0.65	0.59
0.72	0.69	0.77	0.83	1.39	1.87	1.93	1.96	1.57	1	0.94	0.76	0.72
0.89	0.83	0.79	1	1.26	1.67	1.86	1.34	1.45	1	1.04	0.99	0.82
1.02	0.89	0.81	0.95	1.2	1.41	1.75	1.54	1.37	1.02	1.07	1.02	0.92
0.9	0.85	0.81	0.85	0.99	1.14	1.18	1.1	1.29	0.91	0.83	0.85	0.84
0.67	0.65	0.54	0.61	0.64	0.64	0.69	0.69	0.65	0.65	0.66	0.74	0.72
0.5	0.47	0.49	0.44	0.48	0.43	0.43	0.41	0.44	0.47	0.55	0.63	0.6
0.14	0.17	0.15	0.17	0.14	0.16	0.16	0.17	0.15	0.23	0.24	0.27	0.27

Curb

Curb

Vendor 2 – 95W

Median



0.66	0.65	0.63	0.82	1.07	1.44	1.84	1.65	1.34	1.34	0.99	0.75	0.53
0.71	0.66	0.65	0.71	0.89	1.08	1.34	1.18	1.1	1.1	0.94	0.8	0.6
0.74	0.71	0.61	0.71	0.87	1.01	1.17	1.14	1.04	1.04	0.83	0.79	0.68
0.72	0.7	0.65	0.72	0.81	0.96	1.03	1.04	1.03	1.03	0.88	0.76	0.68
0.76	0.68	0.64	0.7	0.74	0.82	0.9	0.96	0.92	0.92	0.84	0.85	0.7
0.8	0.75	0.71	0.62	0.67	0.76	0.83	0.83	0.82	0.82	0.87	0.92	0.75
0.85	0.77	0.87	0.66	0.66	0.75	0.82	0.8	0.74	0.74	0.99	0.93	0.82
0.74	0.73	0.57	0.48	0.51	0.6	0.66	0.57	0.43	0.43	0.54	0.6	0.62

Curb

Curb

Min	Max	Avg	Uniformity
0.43	1.84	0.83	1.93



PILOT STUDY

Vendor 3 - 142W Median



Min	Max	Avg	Uniformity
0.06	4.03	1.12	18.66

0.75	0.79	0.99	1.52	2.68	3.96	4.03	3.79	2.57	1.52	1.06	0.88	0.87
0.75	0.8	1.03	1.5	2.28	3.11	3.4	2.97	2.14	1.44	1.08	0.91	0.93
0.77	0.84	1.03	1.49	1.93	2.46	2.51	2.38	1.85	1.35	1.03	0.91	0.92
0.78	0.8	0.98	1.25	1.39	1.97	1.94	1.84	1.48	1.17	0.96	0.9	0.87
0.71	0.78	0.84	1.04	1.16	1.38	1.27	1.25	1.1	0.96	0.84	0.81	0.79
0.63	0.7	0.75	0.82	0.85	0.81	0.78	0.8	0.74	0.73	0.71	0.72	0.69
0.59	0.6	0.72	0.68	0.64	0.6	0.52	0.56	0.54	0.54	0.57	0.61	0.62
0.29	0.28	0.26	0.23	0.17	0.15	0.06	0.11	0.12	0.14	0.18	0.21	0.24

Curb

Curb

Vendor 4 - 120W Median



0.32	0.32	0.49	0.64	0.99	2.25	2.34	2.38	1.26	0.83	0.65	0.4	0.38
0.38	0.39	0.62	0.84	1.44	2.23	1.74	2.16	1.52	0.97	0.68	0.49	0.46
0.43	0.43	0.63	0.85	1.53	1.71	1.75	1.66	1.62	0.96	0.68	0.51	0.48
0.46	0.45	0.61	0.85	1.42	1.35	1.51	1.27	1.3	0.86	0.75	0.52	0.52
0.48	0.48	0.68	0.82	1.06	1.1	1.17	1.12	1.16	0.87	0.82	0.57	0.55
0.5	0.52	0.69	0.87	1.18	1.33	1.44	1.29	1.25	0.98	0.69	0.57	0.55
0.5	0.52	0.6	0.87	1.08	1.18	1.47	1.38	1.15	0.88	0.64	0.58	0.56
0.38	0.42	0.46	0.55	0.64	0.65	0.62	0.58	0.55	0.49	0.42	0.43	0.37

Curb

Curb

Min	Max	Avg	Uniformity
0.32	2.38	0.89	2.79

Comparison



Median

Vendor 1

Curb

10' from Curb

Vendor 2

Vendor 3

Vendor 4

0.57	0.58	0.66	0.9	1.48	2.04	1.95	2.13	1.65	0.96	0.75	0.65	0.59
0.72	0.69	0.77	0.83	1.39	1.87	1.93	1.96	1.57	1	0.94	0.76	0.72
0.89	0.83	0.79	1	1.26	1.67	1.86	1.34	1.45	1	1.04	0.99	0.82
1.02	0.89	0.81	0.95	1.2	1.41	1.75	1.54	1.37	1.02	1.07	1.02	0.92
0.9	0.85	0.81	0.85	0.99	1.14	1.18	1.1	1.29	0.91	0.83	0.85	0.84
0.67	0.65	0.54	0.61	0.64	0.64	0.69	0.69	0.65	0.65	0.66	0.74	0.72
0.5	0.47	0.49	0.44	0.48	0.43	0.43	0.41	0.44	0.47	0.55	0.63	0.6
0.14	0.17	0.15	0.17	0.14	0.16	0.16	0.17	0.15	0.23	0.24	0.27	0.27

0.66	0.65	0.63	0.82	1.07	1.44	1.84	1.65	1.34	1.34	0.99	0.75	0.53
0.71	0.66	0.65	0.71	0.89	1.08	1.34	1.18	1.1	1.1	0.94	0.8	0.6
0.74	0.71	0.61	0.71	0.87	1.01	1.17	1.14	1.04	1.04	0.83	0.79	0.68
0.72	0.7	0.65	0.72	0.81	0.96	1.03	1.04	1.03	1.03	0.88	0.76	0.68
0.76	0.68	0.64	0.7	0.74	0.82	0.9	0.96	0.92	0.92	0.84	0.85	0.7
0.8	0.75	0.71	0.62	0.67	0.76	0.83	0.83	0.82	0.82	0.87	0.92	0.75
0.85	0.77	0.87	0.66	0.66	0.75	0.82	0.8	0.74	0.74	0.99	0.93	0.82
0.74	0.73	0.57	0.48	0.51	0.6	0.66	0.57	0.43	0.43	0.54	0.6	0.62

0.75	0.79	0.99	1.52	2.68	3.96	4.03	3.79	2.57	1.52	1.06	0.88	0.87
0.75	0.8	1.03	1.5	2.28	3.11	3.4	2.97	2.14	1.44	1.08	0.91	0.93
0.77	0.84	1.03	1.49	1.93	2.46	2.51	2.38	1.85	1.35	1.03	0.91	0.92
0.78	0.8	0.98	1.25	1.39	1.97	1.94	1.84	1.48	1.17	0.96	0.9	0.87
0.71	0.78	0.84	1.04	1.16	1.38	1.27	1.25	1.1	0.96	0.84	0.81	0.79
0.63	0.7	0.75	0.82	0.85	0.81	0.78	0.8	0.74	0.73	0.71	0.72	0.69
0.59	0.6	0.72	0.68	0.64	0.6	0.52	0.56	0.54	0.54	0.57	0.61	0.62
0.29	0.28	0.26	0.23	0.17	0.15	0.06	0.11	0.12	0.14	0.18	0.21	0.24

0.32	0.32	0.49	0.64	0.99	2.25	2.34	2.38	1.26	0.83	0.65	0.4	0.38
0.38	0.39	0.62	0.84	1.44	2.23	1.74	2.16	1.52	0.97	0.68	0.49	0.46
0.43	0.43	0.63	0.85	1.53	1.71	1.75	1.66	1.62	0.96	0.68	0.51	0.48
0.46	0.45	0.61	0.85	1.42	1.35	1.51	1.27	1.3	0.86	0.75	0.52	0.52
0.48	0.48	0.68	0.82	1.06	1.1	1.17	1.12	1.16	0.87	0.82	0.57	0.55
0.5	0.52	0.69	0.87	1.18	1.33	1.44	1.29	1.25	0.98	0.69	0.57	0.55
0.5	0.52	0.6	0.87	1.08	1.18	1.47	1.38	1.15	0.88	0.64	0.58	0.56
0.38	0.42	0.46	0.55	0.64	0.65	0.62	0.58	0.55	0.49	0.42	0.43	0.37



LEE ENGINEERING

LIGHT LEVEL MEASUREMENT COMPARISON

Measurement Area Includes – 10' beyond curb

	MH 295W	Vendor 1 190W	Vendor 2 95W	Vendor 3 142W	Vendor 4 120W
Min	0.16	0.14	0.43	0.06	0.32
Max	2.68	1.96	1.84	4.03	2.38
Avg	0.71	0.82	0.83	1.12	0.95
Uniformity	4.45	5.88	1.93	18.66	2.97

Measurement Area - Only Pavement

	MH 295W	Vendor 1 190W	Vendor 2 95W	Vendor 3 142W	Vendor 4 120W
Min	0.28	0.41	0.53	0.52	0.32
Max	2.68	2.13	1.84	4.03	2.38
Avg	0.77	0.96	0.87	1.25	0.95
Uniformity	2.76	2.34	1.63	2.41	2.97

ENERGY SAVINGS

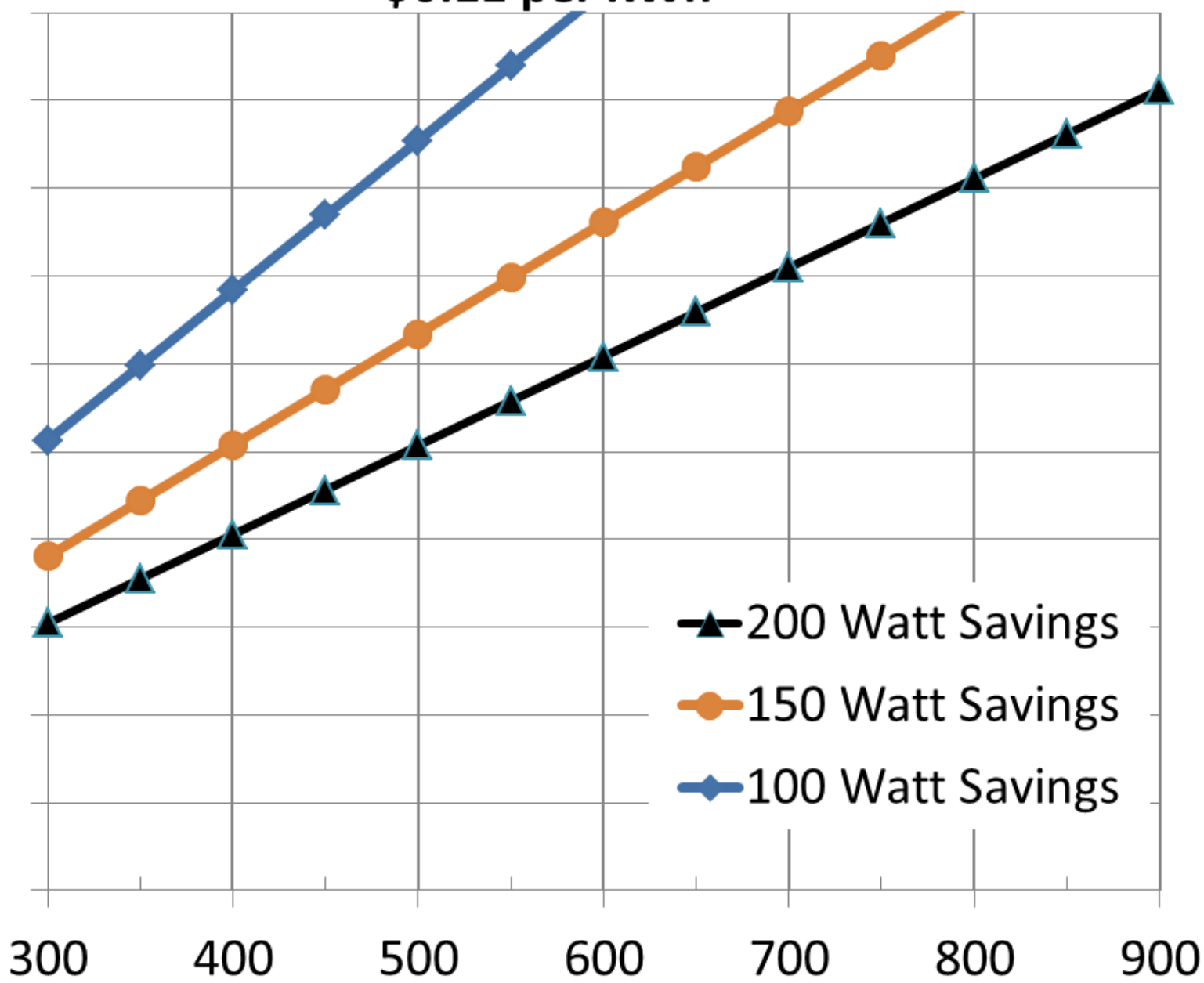
Existing MH	Vendor 1	Vendor 2	Vendor 3	Vendor 4
295W	190W	95W	142W	119W
Energy Savings	36%	67%	52%	60%

PAYBACK ANALYSIS

	Existing MH	Vendor 1	Vendor 2	Vendor 3	Vendor 4
Initial Purchase	-	\$600	\$450	\$700	\$600
Yearly Energy Cost @ 0.11kWh	\$124.36	\$80	\$40	\$60	\$50.25
Yearly Maint. Cost	\$17.78	\$3.5	\$3.5	\$3.5	\$3.5
5 Yr. Cumulative Cost	\$711	\$997	\$667	\$1001	\$855
10 Yr. Cumulative Cost	\$1421	\$1262	\$885	\$1333	\$1138
Years Payback		10.25	4.56	8.88	6.79

Years to Payback

\$0.11 per KWh

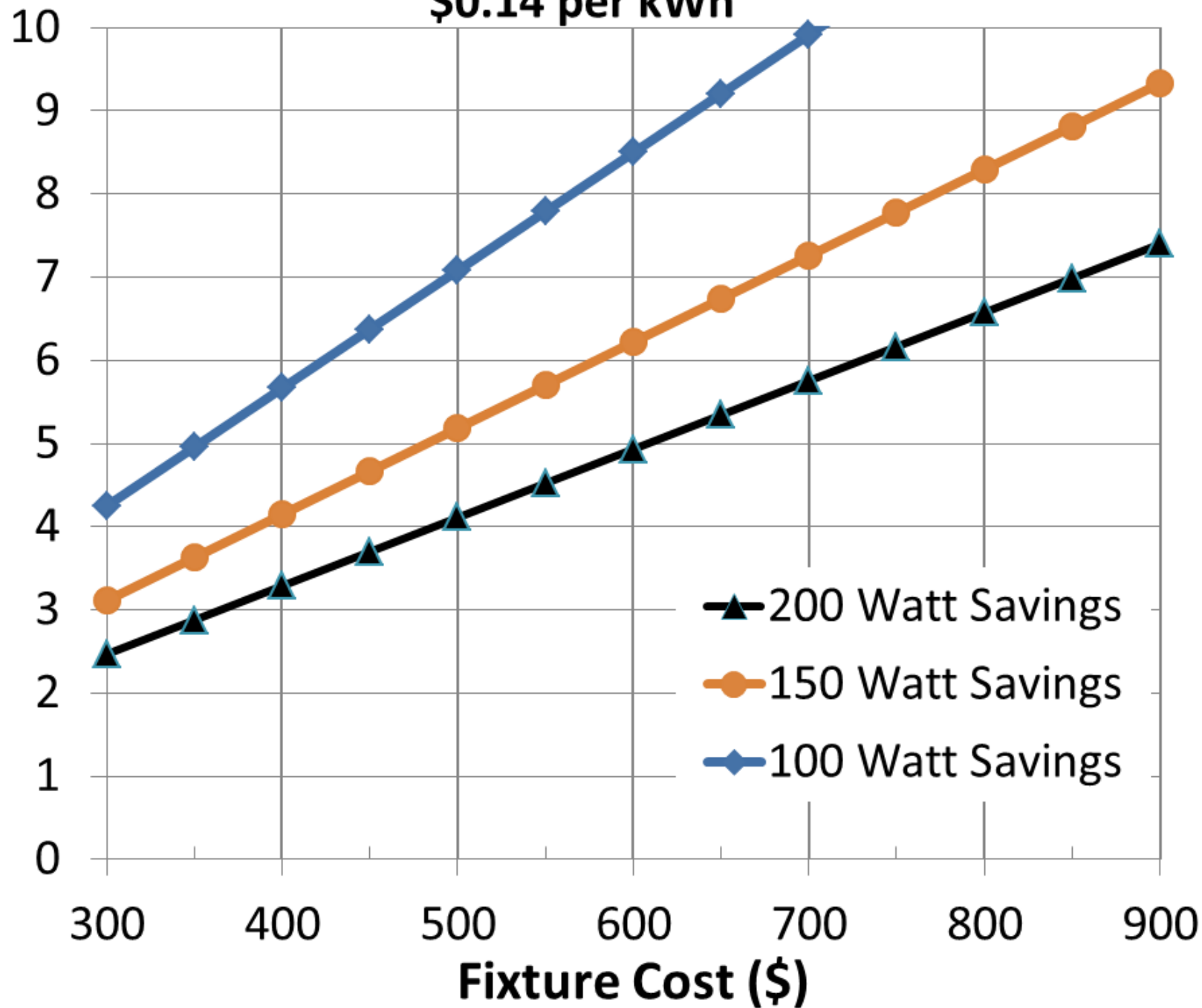


- ▲ 200 Watt Savings
- 150 Watt Savings
- ◆ 100 Watt Savings

Fixture Cost (\$)

\$0.14 per kWh

Years to Payback



WHERE ARE WE NOW?

- LED is our standard for new installs
- Recent bid to finish replacement of arterial lighting
- All LED by December 2017 except for Post Top
- Post Top lamps more expensive to convert
- Payback just over 2 years and about 6-7 years depending on power rate
- Starting to explore control systems

WHERE ARE NOW?

LED Conversion Status

Total Fixtures	6,413
Total LED Fixtures	4,189
Total LED Conversions	2,864
Total LEDs installed as new construction	1,325
Fixtures remaining to convert	2,224 (1640 Cobra, 584 Post Top)
Percent of conversion complete	56% (2864/5088)
Percent of system LED	65%

RECOMMENDATIONS

- Require a minimum 10 year warranty
- Don't forget control systems – at least get lamp with NEMA socket allow flexibility later
- Think Smart City applications
- Costs continue to drop, rate has slowed though
- Know your kWh rates, large impact on payback
- Be aware of finance options for change out

QUESTIONS?

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