Illuminating
ENGINEERING SOCIETY

EPRI's
Energy Efficiency Demonstration

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IES 2010 Street and Area Lighting Conference
September 27, 2010

LEDs are Everywhere

Source: http://www.ecouterre.com/4910/led-eyelashes-designed-to-brighten-enlarge-eyes/led-eyelashes-1/

Which Leads To…

Demonstrations:

Evansville to save 80,000 kW/hrs with LED street lights…

The city of Yakima, Washington, initiated the first phase of an LED streetlight retrofit program in July 2010. The deployment involves replacement of 459 …

July 29, 2010, Russian City Saves $26,000 Annually with LED Street Lighting. The city of Kemerovo in Siberia…

A ***federal stimulus award*** and local matching funds have been awarded to Central City, Nebraska, for an LED streetlight replacement project. ***Funding of $235,836***…

What Are We Getting?

DATA!

SHOW ME THE ~~MONEY!~~

"I never guess. It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts."

– Sherlock Holmes

Agenda

The importance of LEDs for Street and Area Lighting

The big picture and how LEDs fit

What EPRI is doing

Results from the lab

Results from the field (and a new tool)

Lessons learned 12 months in…

Point #1 … It Matters!

Our future depends on it.

Potential savings of 4,500 MWh per year.*

Equivalent to seven 1,000 MW power plants

Equivalent to 3.7 million households

*Assumes 100% installed base. Source: Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications, U.S. Department of Energy, September 2008.

Its Your Money…

Mayor cuts pay of Albuquerque cops…

Philadelphia mayor cuts 2010 budget, city jobs…

Kansas City Braces for School Closings, Budget Cuts…

… Mayor Nutter Signs Legislation, Announces Measures to Increase Energy Efficiency and Save Money

It's Your Industry…

In 1938 the first mercury vapor streetlights were installed…

Light Source	Percentage	Number of Street and Area Lights
Incandescent	2	3,159,000
Halogen Quartz	8	9,917,000
Fluorescent	6	7530,000
Mercury Vapor	13	17,675,000
Metal Halide	27	38,330,000
High Pressure Sodium	39	54,754,000
Total	100	131,356,000

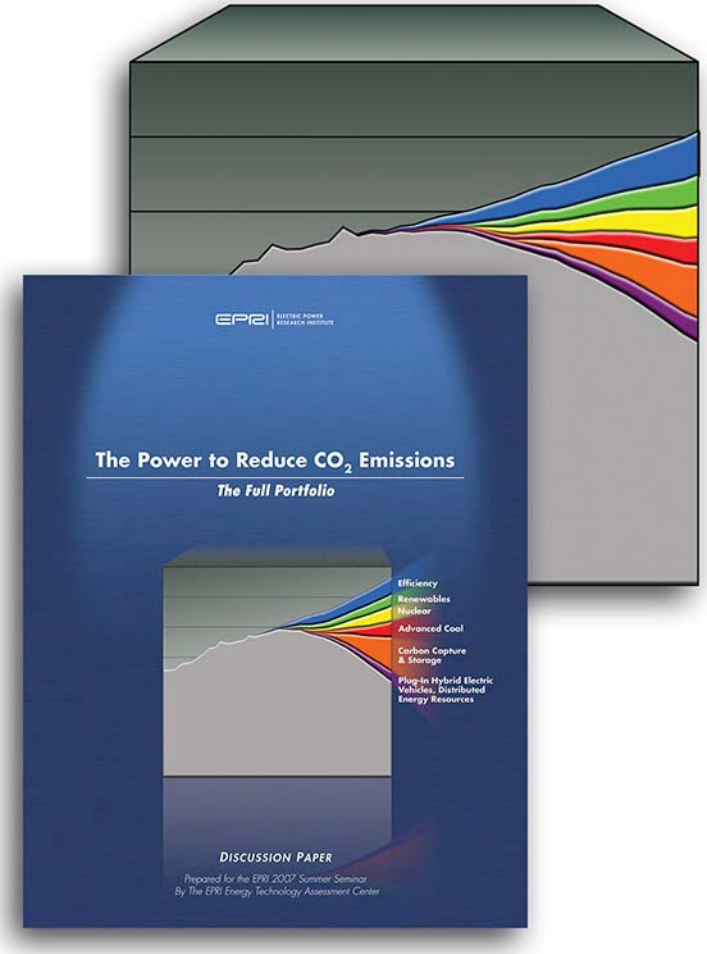
… any many are still there.

Source: Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications. U.S. Department of Energy, September 2008.

Be Careful…

"You don't know until you measure."

The Big Picture



Purpose of EPRI's Prism Merge Analysis:

Assess what technologies will be required to slow … stop … and reverse the increase in CO2 emissions forecast by the Energy Information Administration (EIA)…

EPRI Product ID: 1019563 (free download)

Technologies Addressed in the Prism…

Efficiency

Renewables

Nuclear

Advanced Coal

Carbon Capture and Sequestration

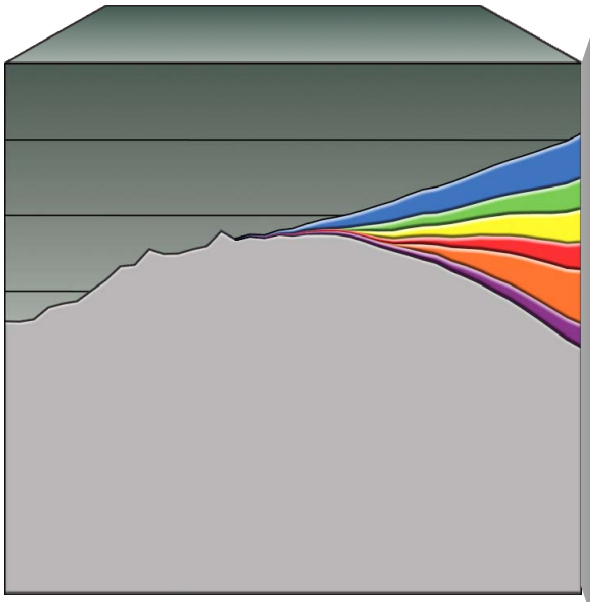
Plug-in Hybrid Electric vehicles (PHEVs)

Distributed Energy Resources

There is no "silver bullet"

…we need them all!

From Analysis to Action…



Technology Challenges	*Demonstration Projects*
Smart Grids and Communication Infrastructure	Smart Grids
Transmission Grids and Associated Energy Storage Infrastructures	Compressed Air Energy Storage
Advanced Light Water Reactors	CCS Using Chilled Ammonia and a Different Technology
Coal-Based Generation Units with CO_2 Capture and Storage	IGCC with CCS
	Low-cost O_2 Production

Field demonstrations of six categories of *hyper-efficient technologies* with the potential to significantly reduce energy usage in U.S. buildings and homes

Variable-Refrigerant-Flow Air Conditioning

Efficient Data-Centers

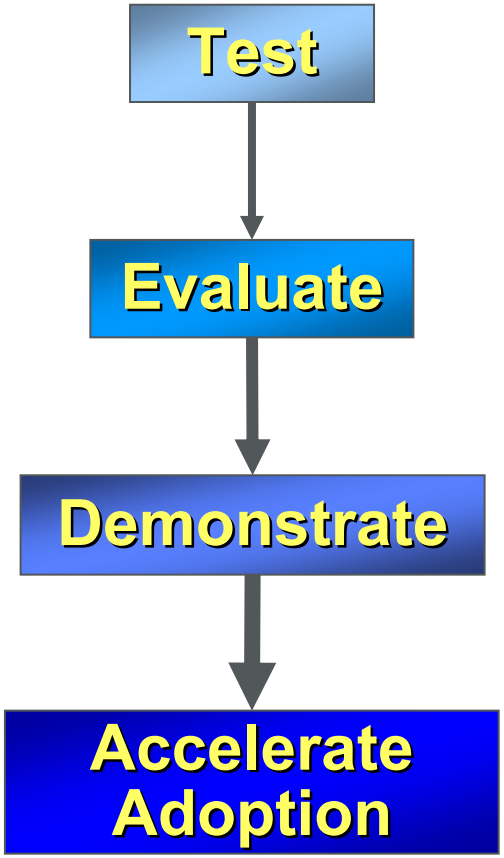
LED Street and Area Lighting

Heat-Pump Water Heaters

Ductless, Residential Heat-Pumps and Air-Conditioners

Hyper-Efficient Residential Appliances

Research Questions



How do these technologies perform?

What level of energy savings?

What about diversity factors?

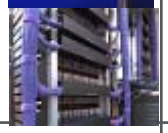
- **manufacturer, climate, electric rates, building design and construction, etc.**

Compatibility with building designs and various codes and standards?

Differences in quality and other effects compared to traditional technologies?

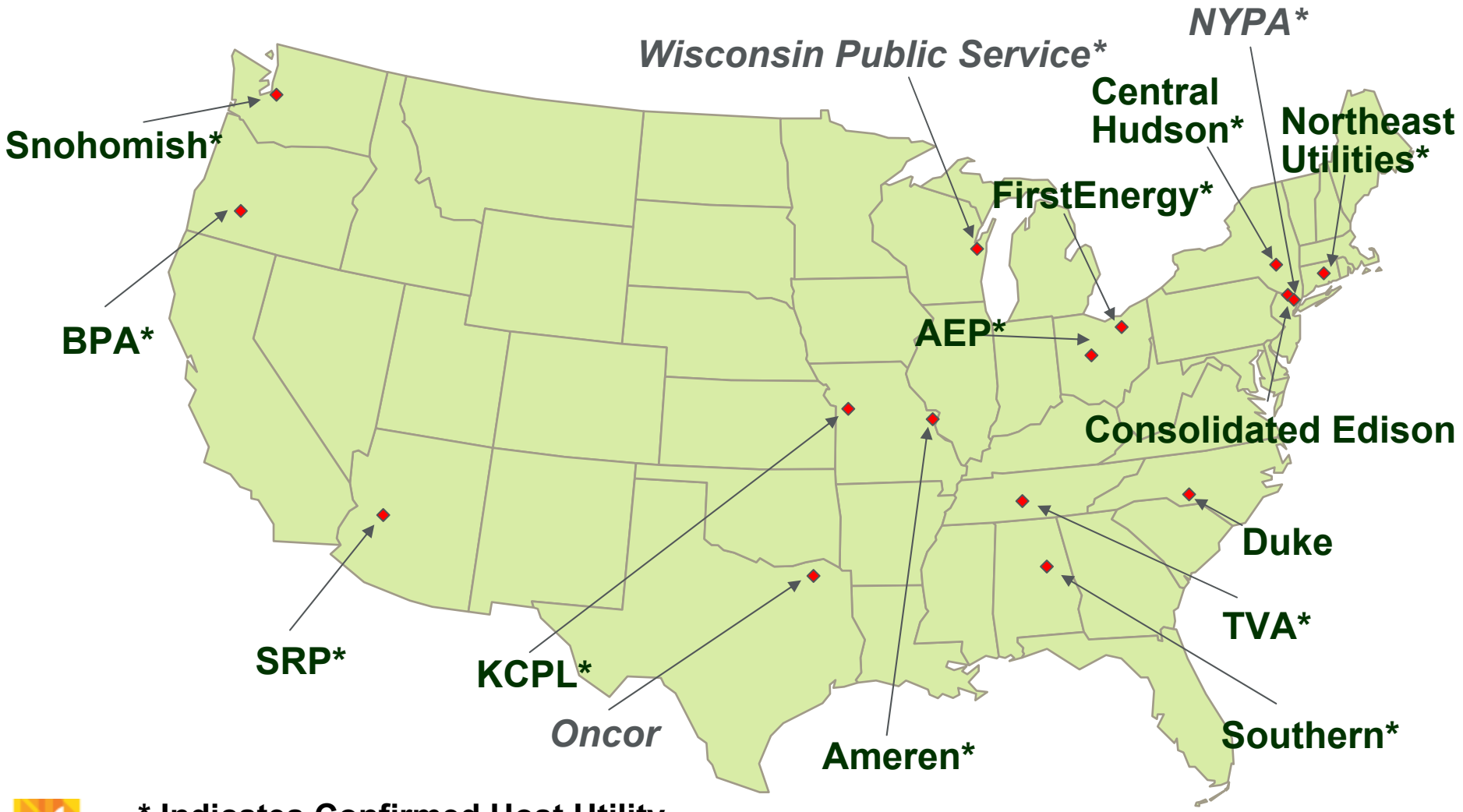
Technical and market obstacles that impede adoption?

Status of Deployment

		Technology	Planned*	Shipped*	Installed*
Commercial		Variable Refrigerant Flow AC	5	2	2
		LED Area Lighting	140	110	100
		Data Centers	5	2	2
Residential		Ductless Heat Pump**	60	6	1
		Heat Pump Water Heater	275	126	22
		Hyper-Efficient Appliances	167	19	12
		TOTAL	**652**	**265**	**139**

* Includes both treatment and control sites
** Does not include 4,000+ devices through Northwest Energy Efficiency Alliance

Committed Collaborators and LED Sites



* Indicates Confirmed Host Utility

LED Streetlight Analysis

Cause → **Measurement** → **Effect**

Technology Factors

- Defined Area Efficacy
- Photometric
- Control Strategies
- Reliability
- Manufacturer

Participant Factors

- Economic
- Demographic
- Behavioral
- Attitudinal
  - EE Preferences
  - Satisfaction
    - Installation
    - Appearance
    - Operation
    - Performance

Instrumentation

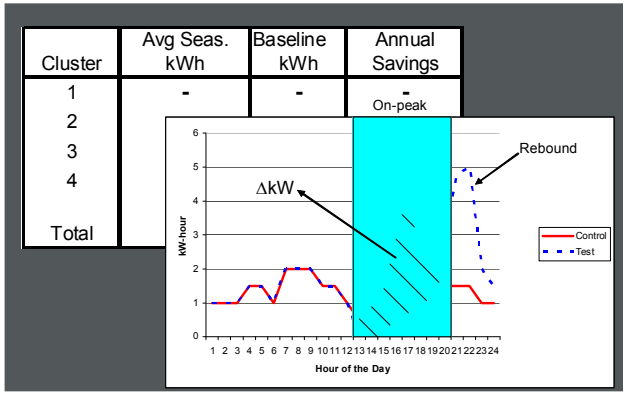
- kWh , kW, Volts, Amps, VAr
- Mobile Light Measurement System (Rover)

Surveys

- Pre-installation
- Post Installation (contractor)
- Post-Install (customer)
- 6 month (periodic)
  - Satisfaction
  - Demographics
- Final

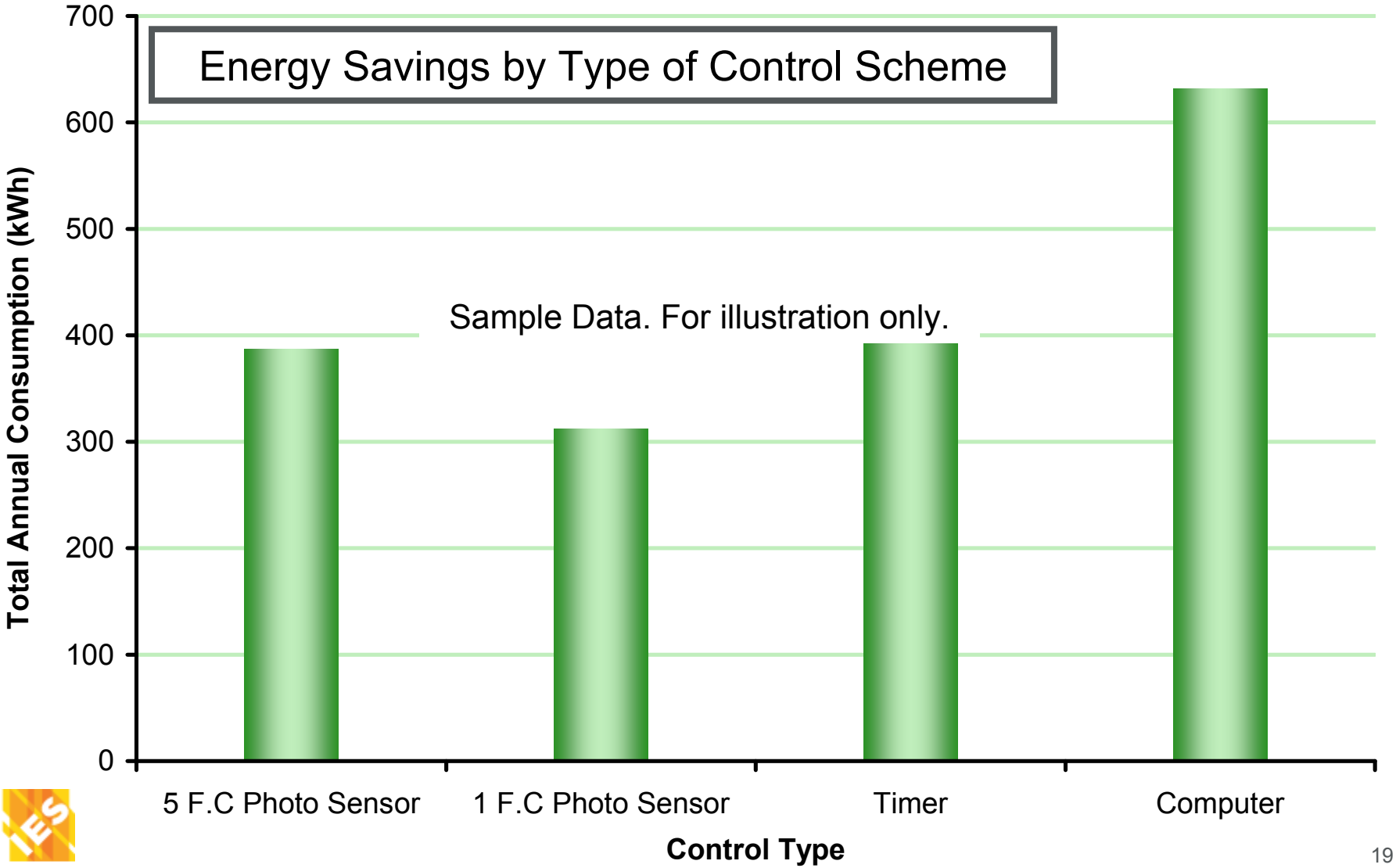
Load Impacts

- kWh Savings by Season
- Peak kW Savings by Season
- Coincident kW Savings by Peak Season
- Rebound
- Demographics & Satisfaction

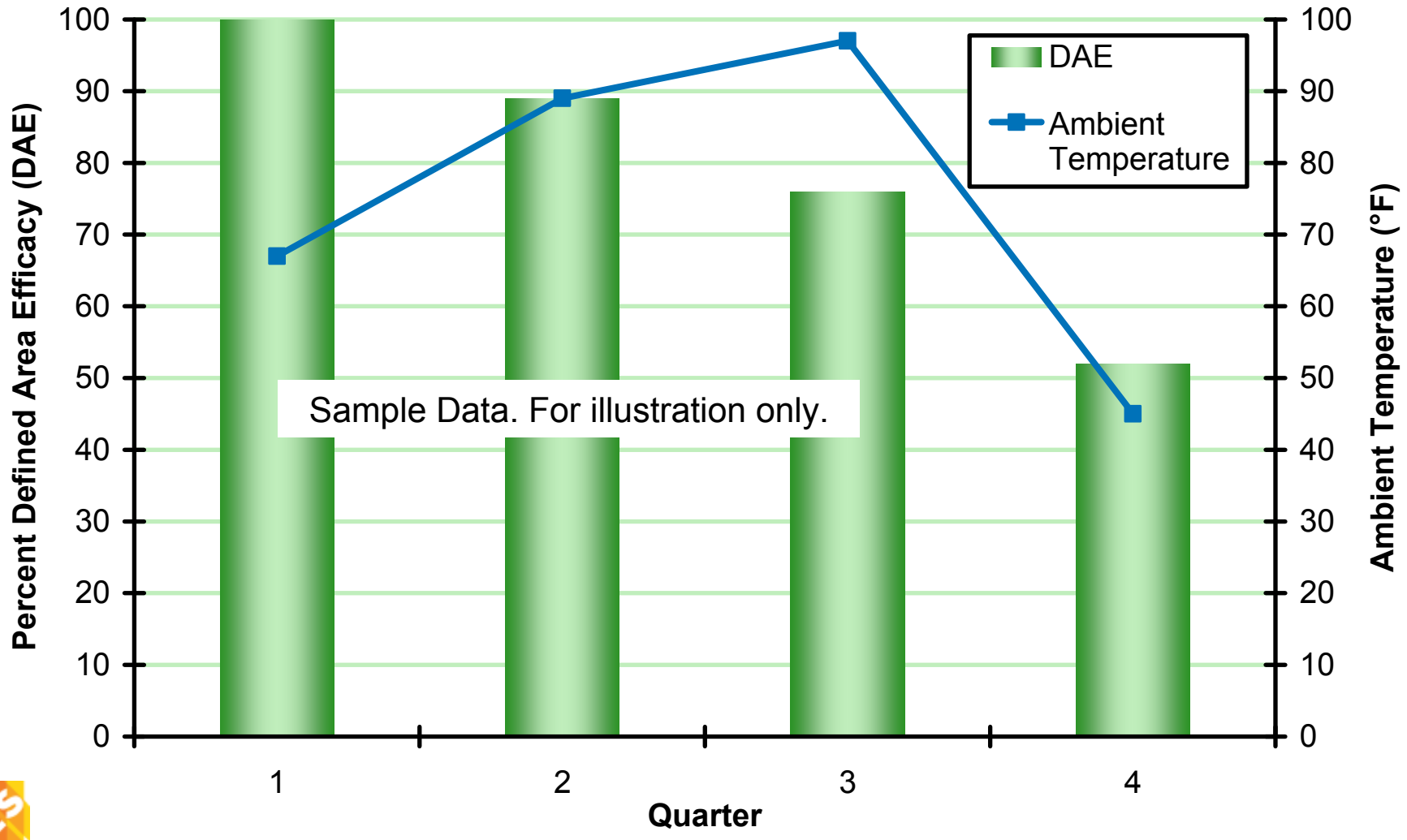


Sample Analytic Slide

F. C. = Foot Candle



Sample Analytic Slide



DAE = Defined Area Efficacy

Survey

City:	Location:

LIGHTING SURVEY

Rate each of the following on a scale of 1 (poor) to 10 (excellent):

1) How would you rate the cleanliness of the area?

1	2	3	4	5	6	7	8	9	10
POOR									EXCELLENT

2) How would you rate the quality of the lighting in the area?

1	2	3	4	5	6	7	8	9	10
POOR									EXCELLENT

3) How would you rate the movie Ghostbusters?

1	2	3	4	5	6	7	8	9	10
POOR									EXCELLENT

The purpose of the survey is to verify that the designs are comparable.

The Ideal Site

Ready access

Low risk

Single electrical circuit

Good pole spacing

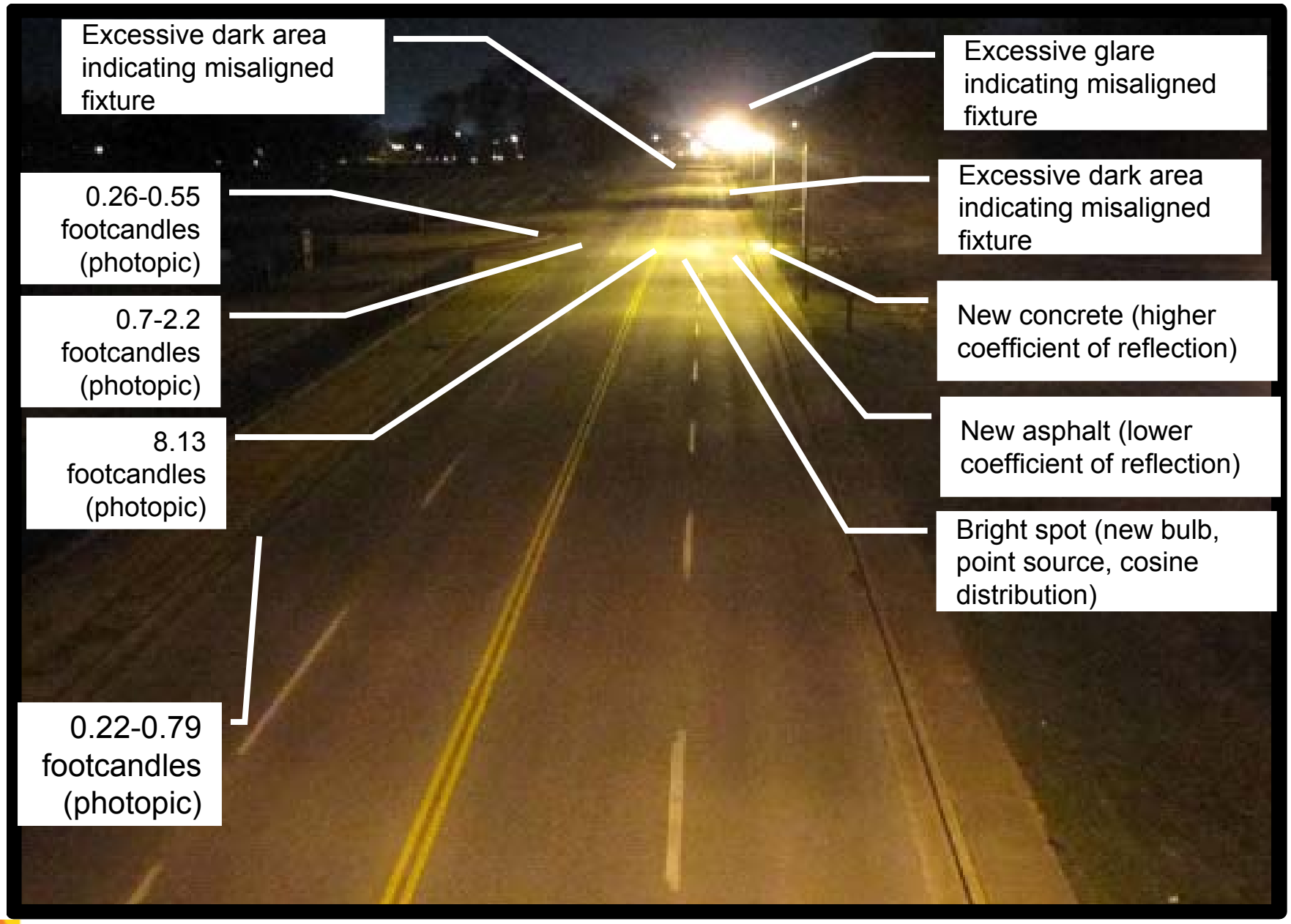
Foot traffic

Minimal light trespass

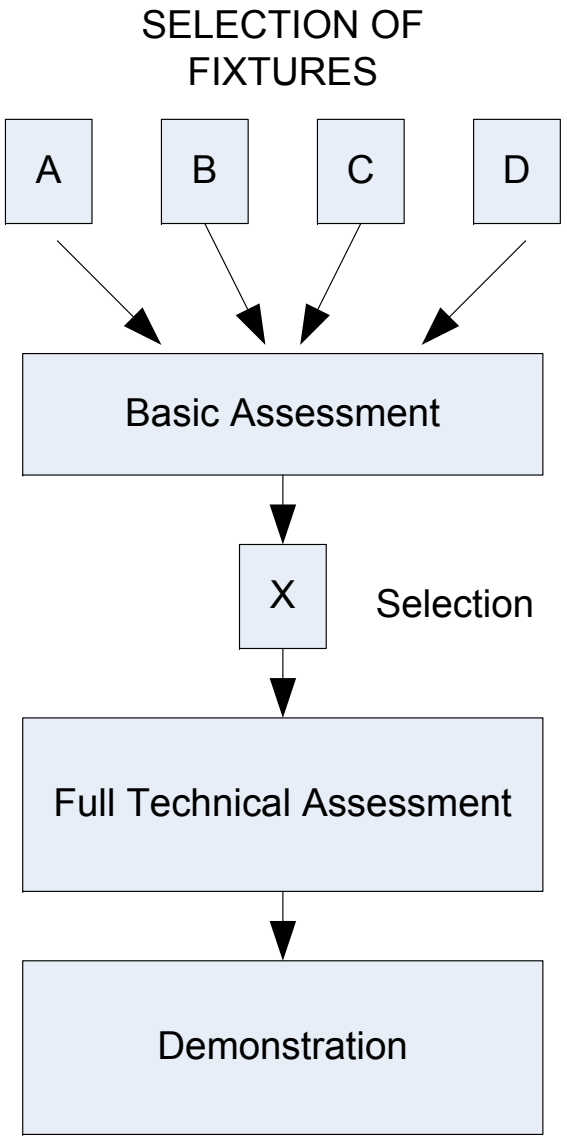
Local buy-in

No vegetation

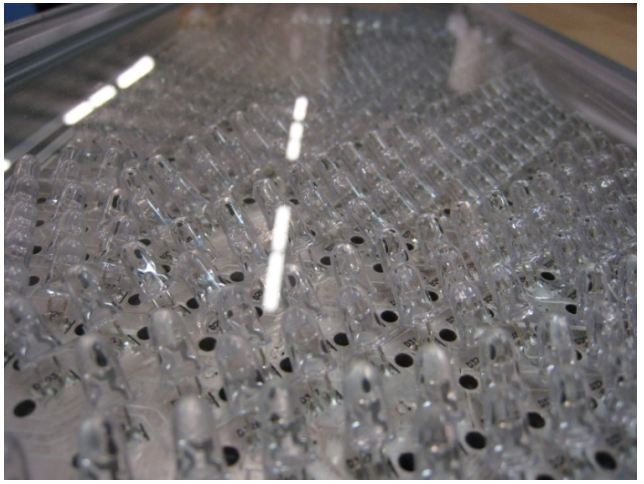
Site Selection

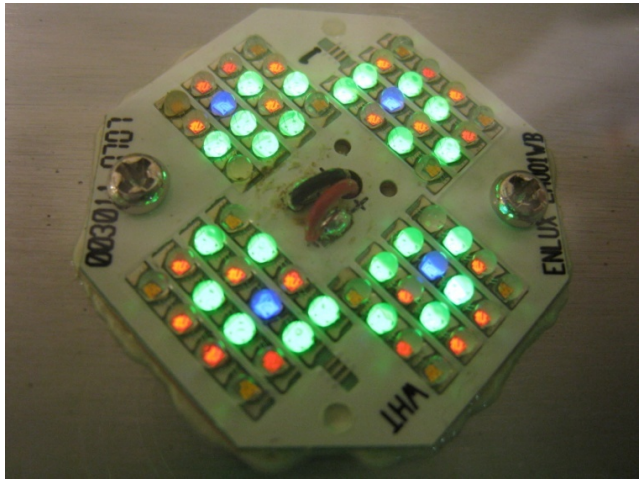

Excessive dark area indicating misaligned fixture
0.26-0.55 footcandles (photopic)
0.7-2.2 footcandles (photopic)
8.13 footcandles (photopic)
0.22-0.79 footcandles (photopic)
Excessive glare indicating misaligned fixture
Excessive dark area indicating misaligned fixture
New concrete (higher coefficient of reflection)
New asphalt (lower coefficient of reflection)
Bright spot (new bulb, point source, cosine distribution)

Process Flow



Design Approaches are Unique…

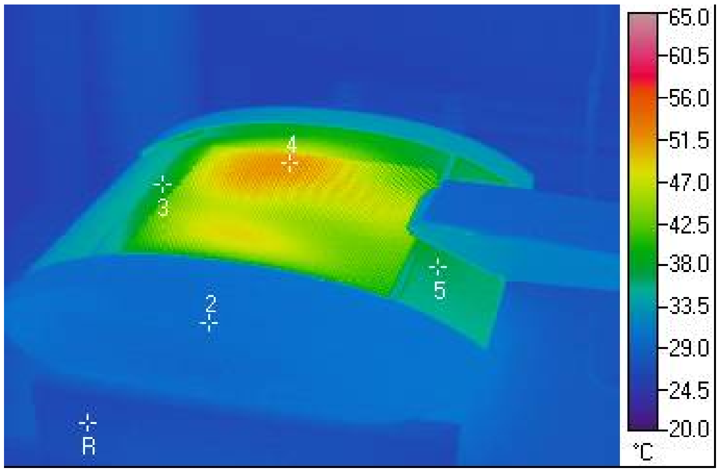


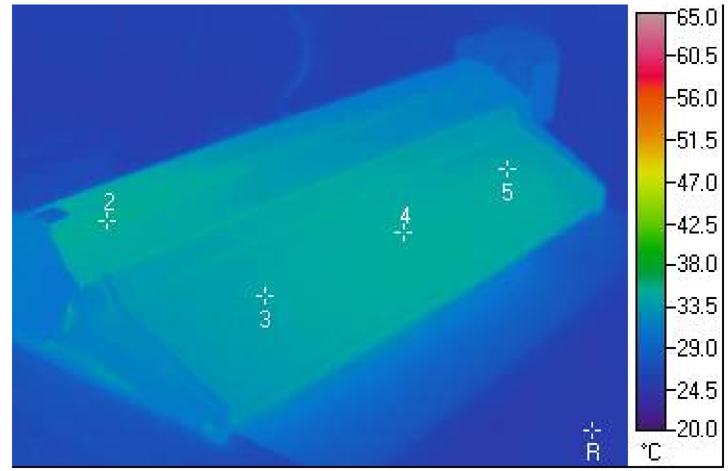


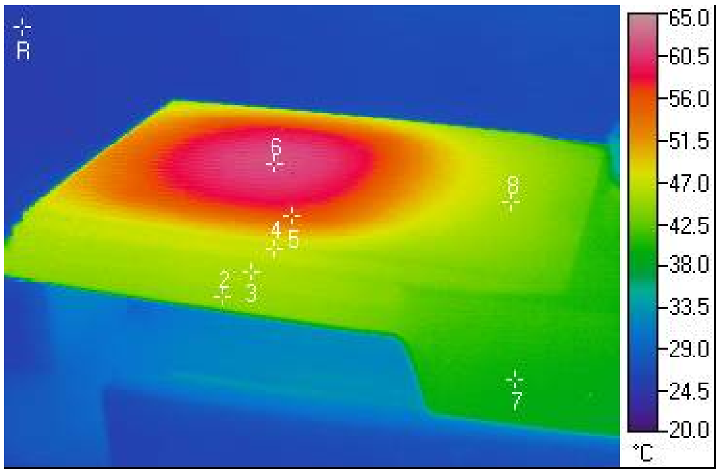
Power Electronics Vary…

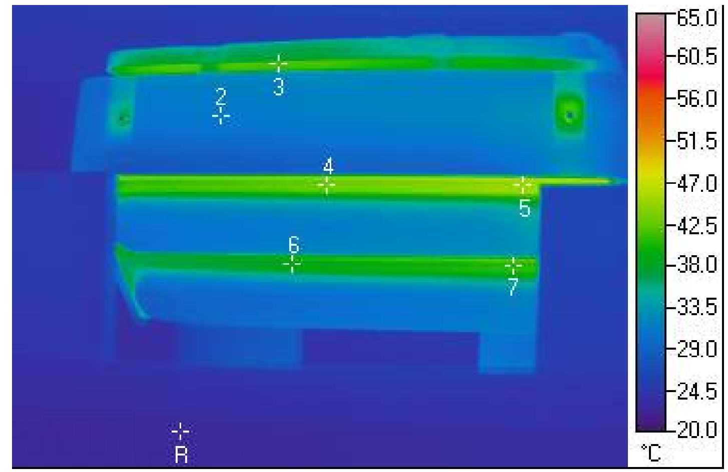
Light Patterns and Color Vary…

Thermal Designs Vary…

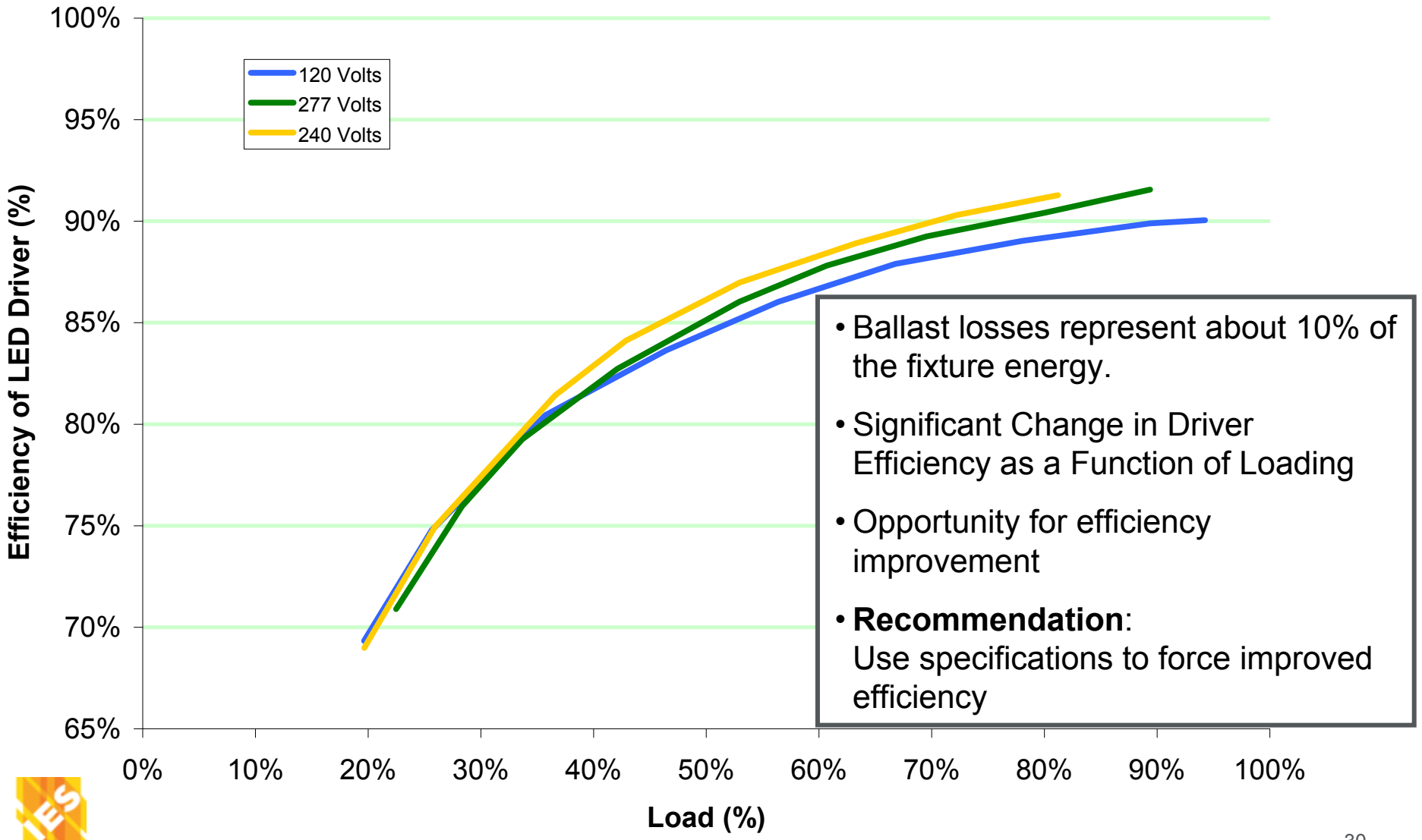






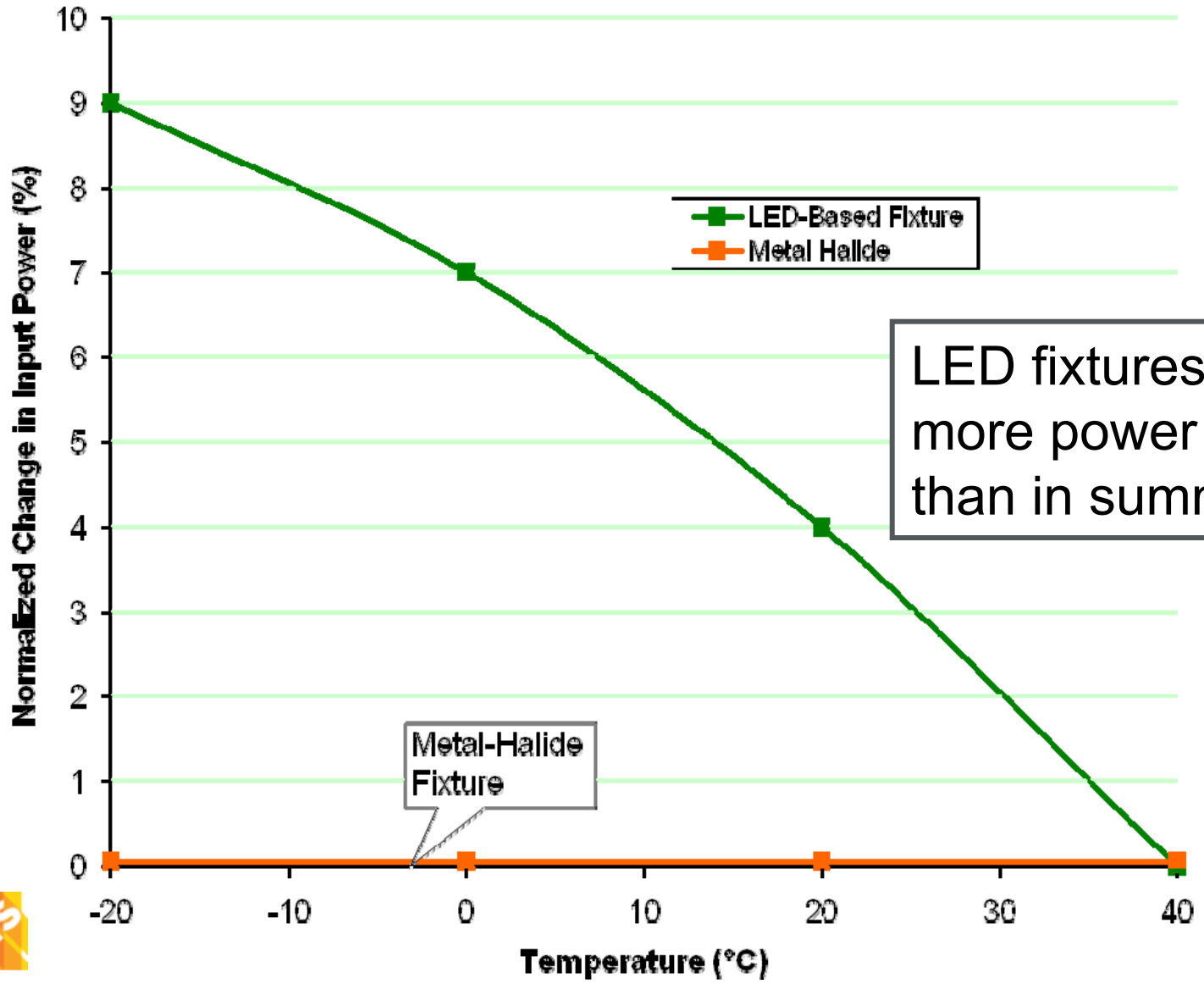


Don’t Forget Driver Efficiency



- Ballast losses represent about 10% of the fixture energy.
- Significant Change in Driver Efficiency as a Function of Loading
- Opportunity for efficiency improvement
- **Recommendation**: Use specifications to force improved efficiency

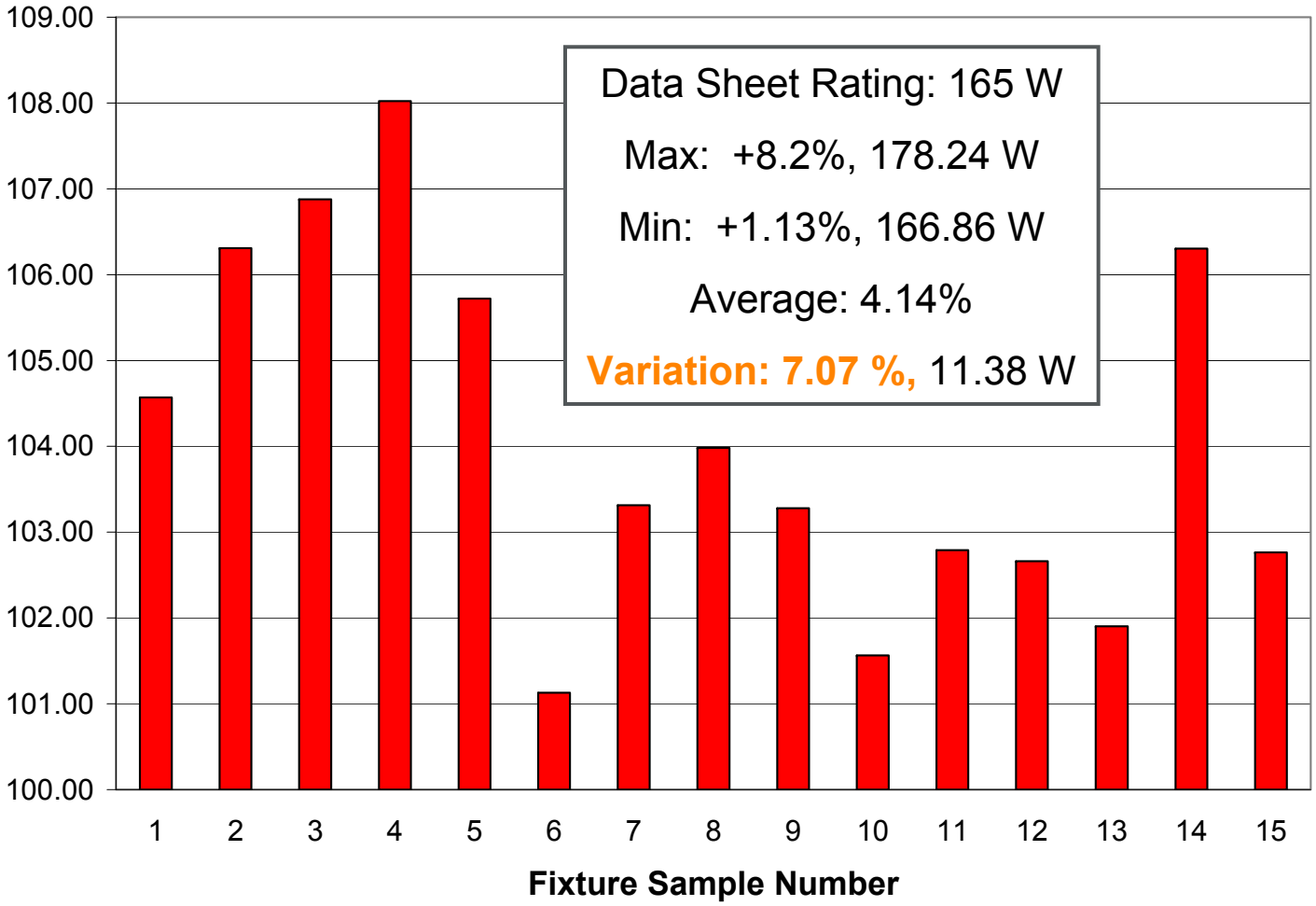
Fixture Power vs. Temperature



LED fixtures require more power in winter than in summer.

How Much Power?

Fixture power expressed as a percent of data sheet rating (165 W)



Not Designed for 480 V

The autotransformer used to step 480 volts down to 277 volts **increased the fixture power consumption by 7.1 %.**

What EPRI is Doing

EPRI is conducting assessments of LED-based street and area lights at over twenty sites within the United States.

Problem:

The assessments require **accurate, repeatable and timely measurements** of light levels.

Existing test methods require hand-held meters and are **time-consuming, of limited accuracy and require manual recording of data**.

You are Here!

The Pale Blue Dot is a photograph of **planet Earth** taken in 1990 by Voyager 1 from a record distance (**3.7 billion miles**), showing it against the vastness of space.

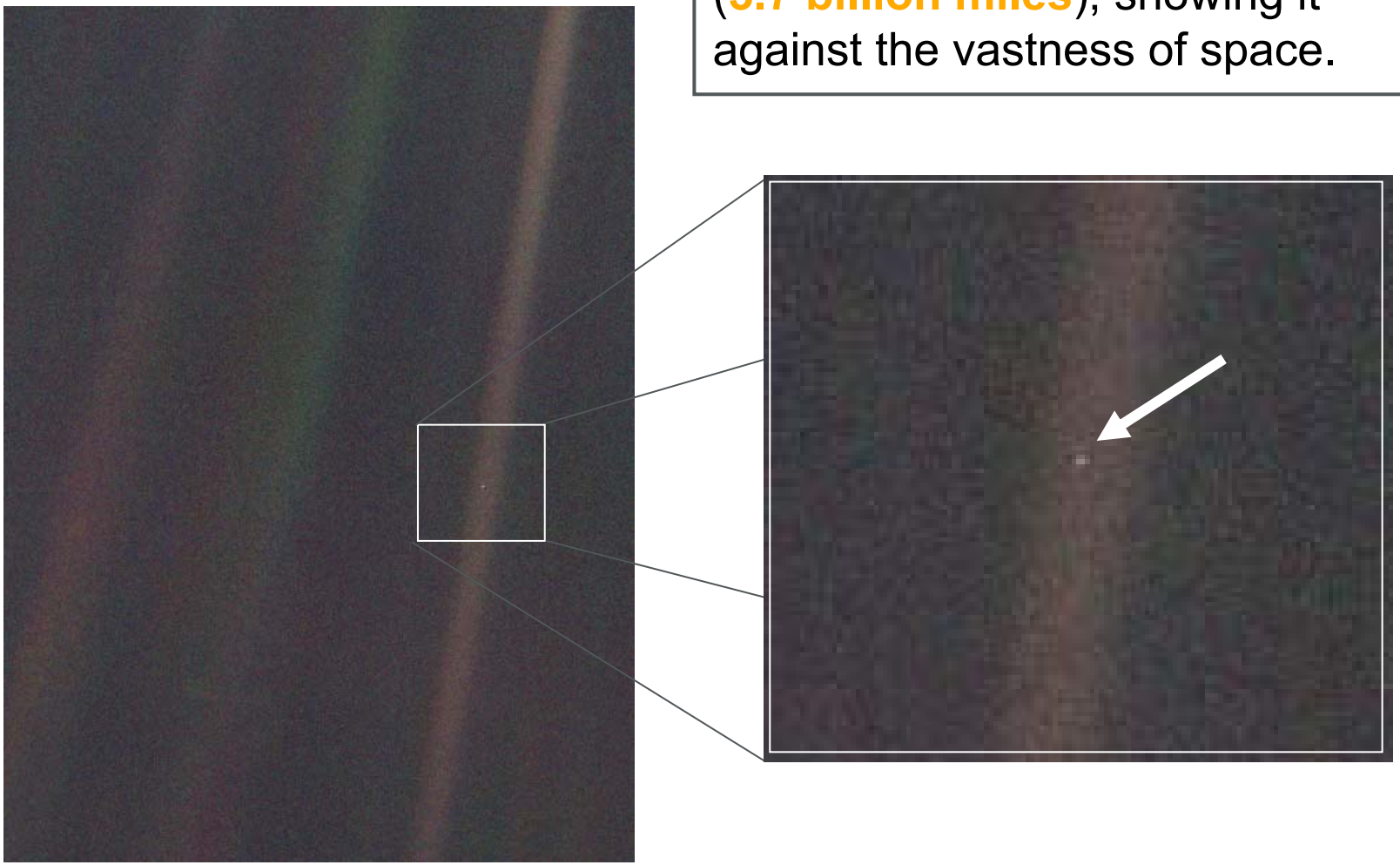
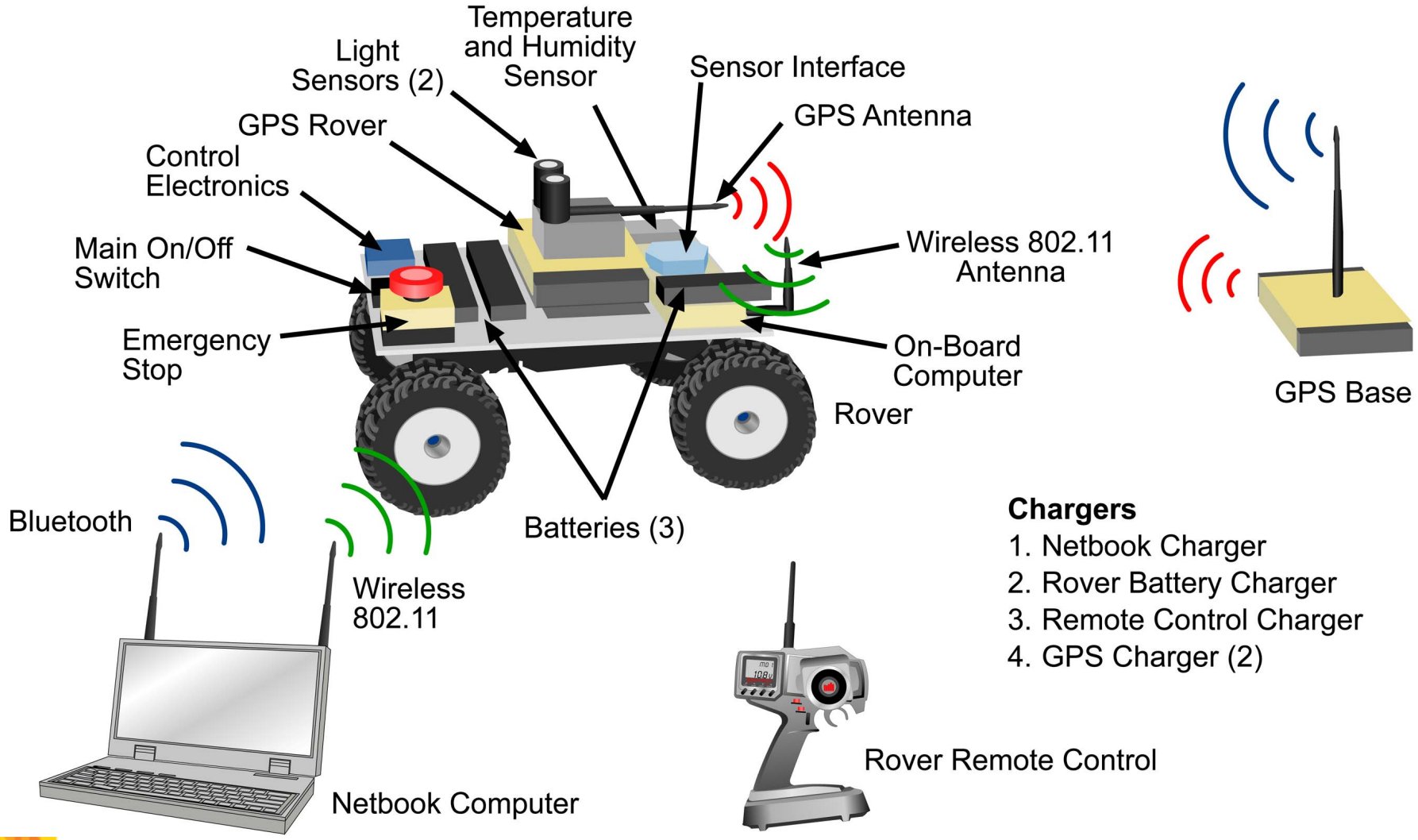


Image source: http://visibleearth.nasa.gov/view_rec.php?id=601

Solution

Mobile Light Measurement System (Rover)

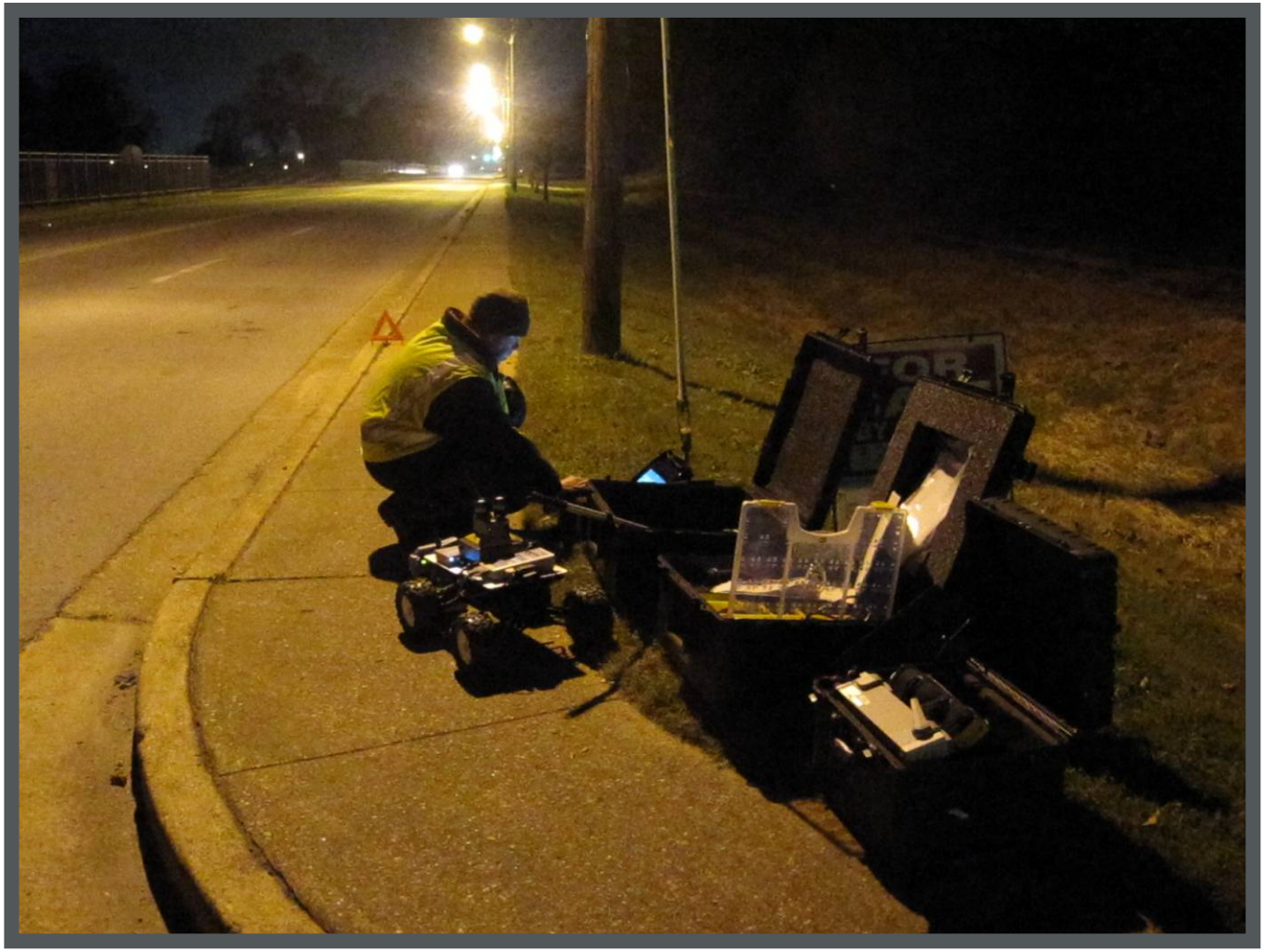
Rover Details



Chargers

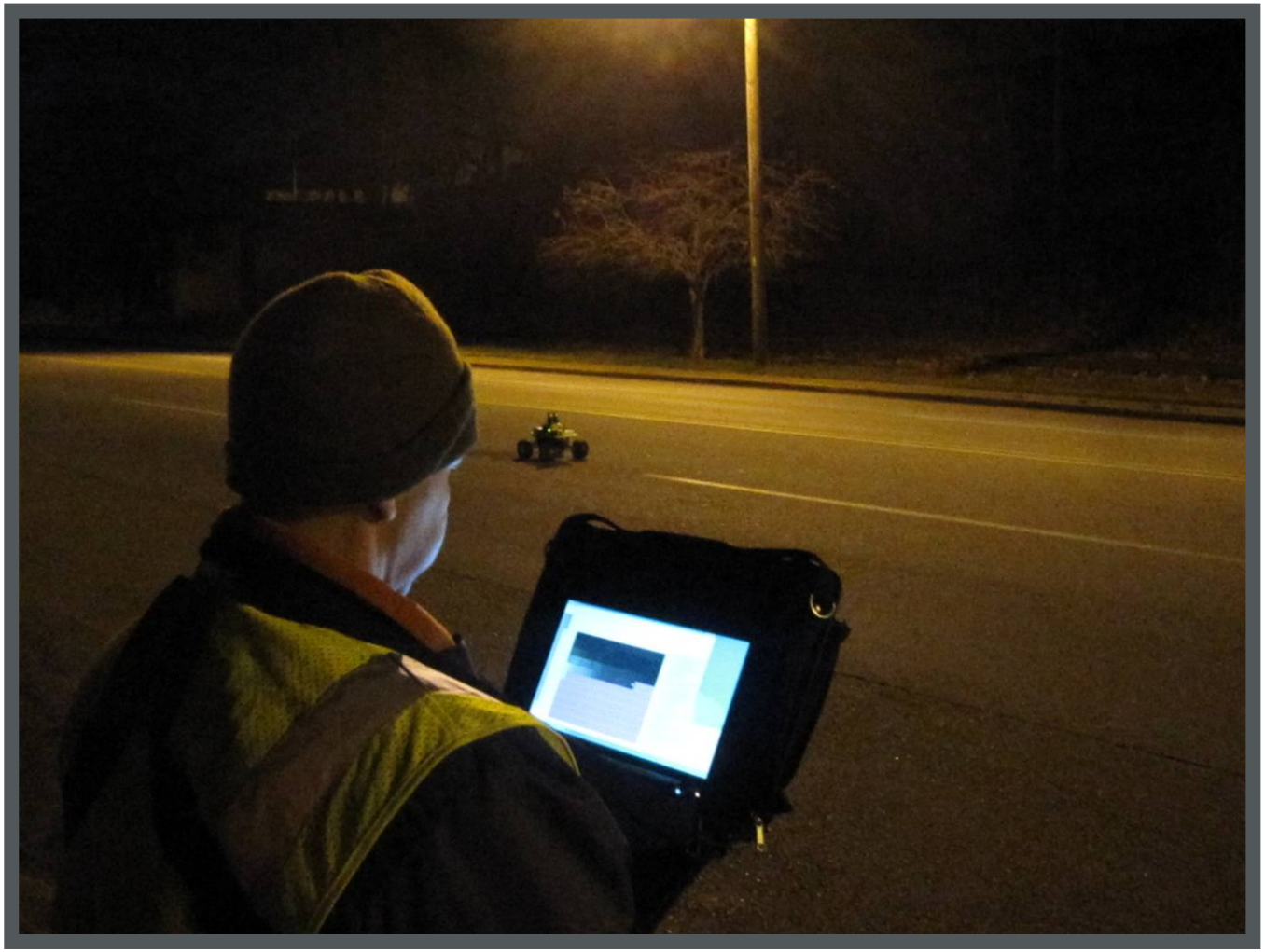
1. Netbook Charger
2. Rover Battery Charger
3. Remote Control Charger
4. GPS Charger (2)

Setup

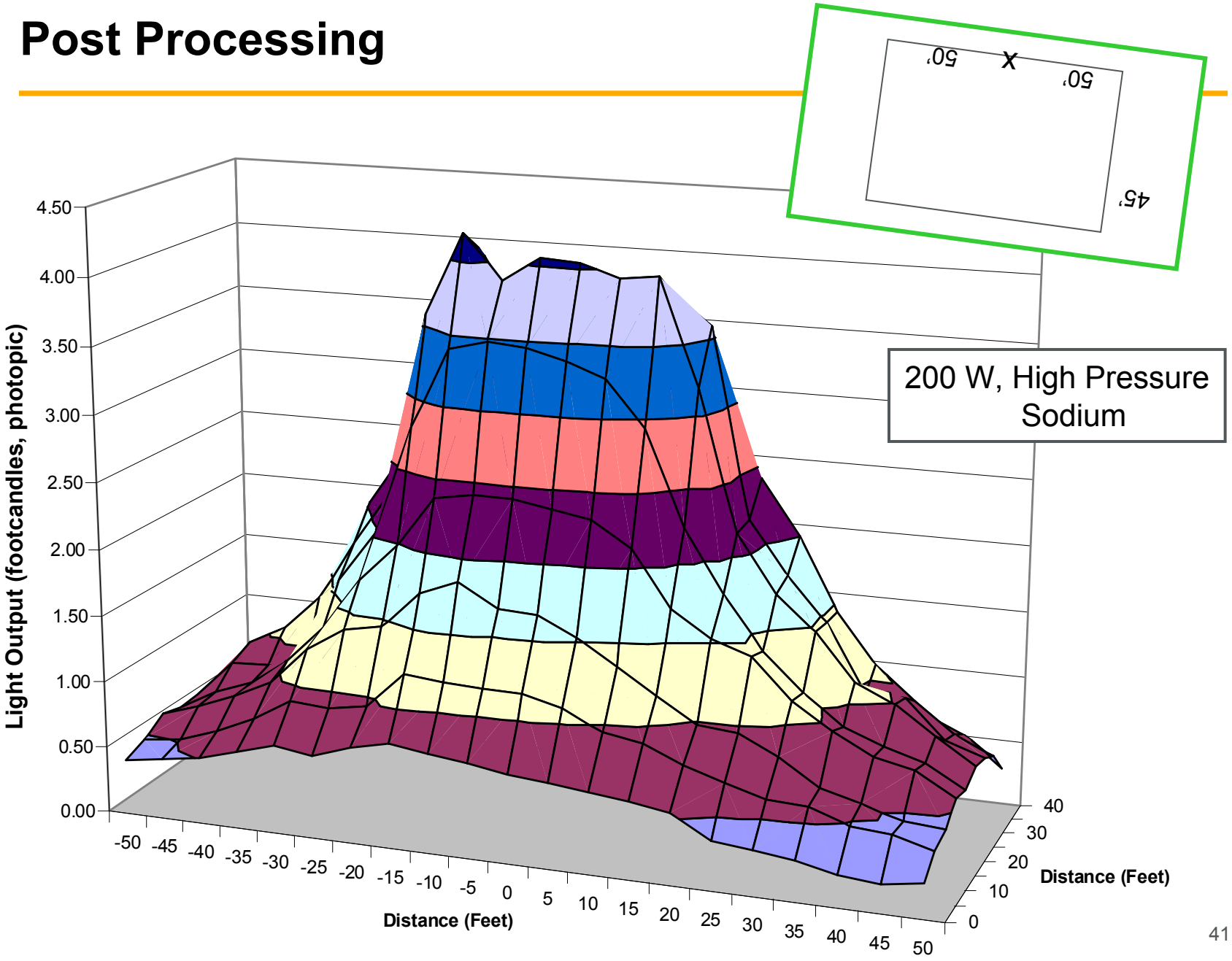


Data Collection

Data Collection



Post Processing



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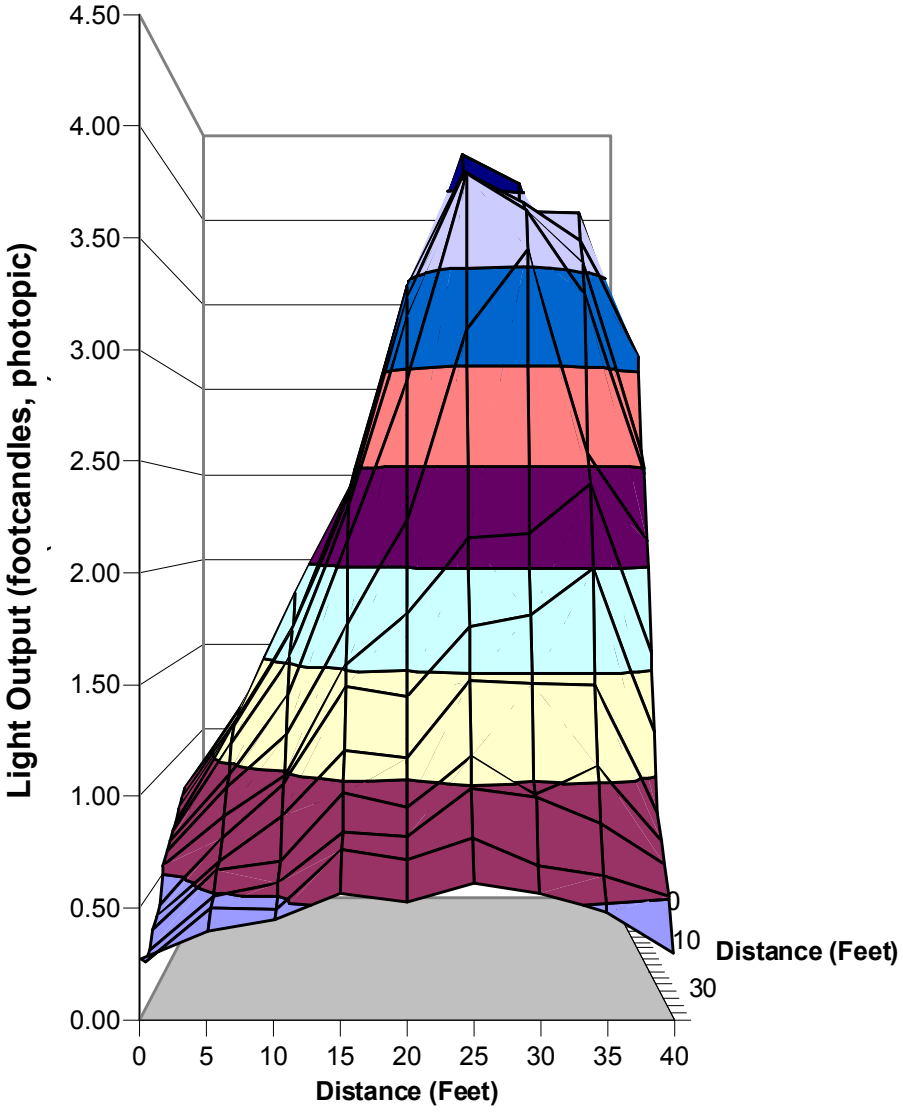

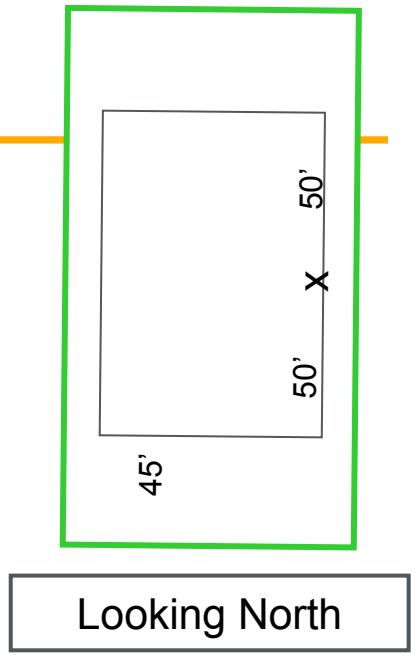

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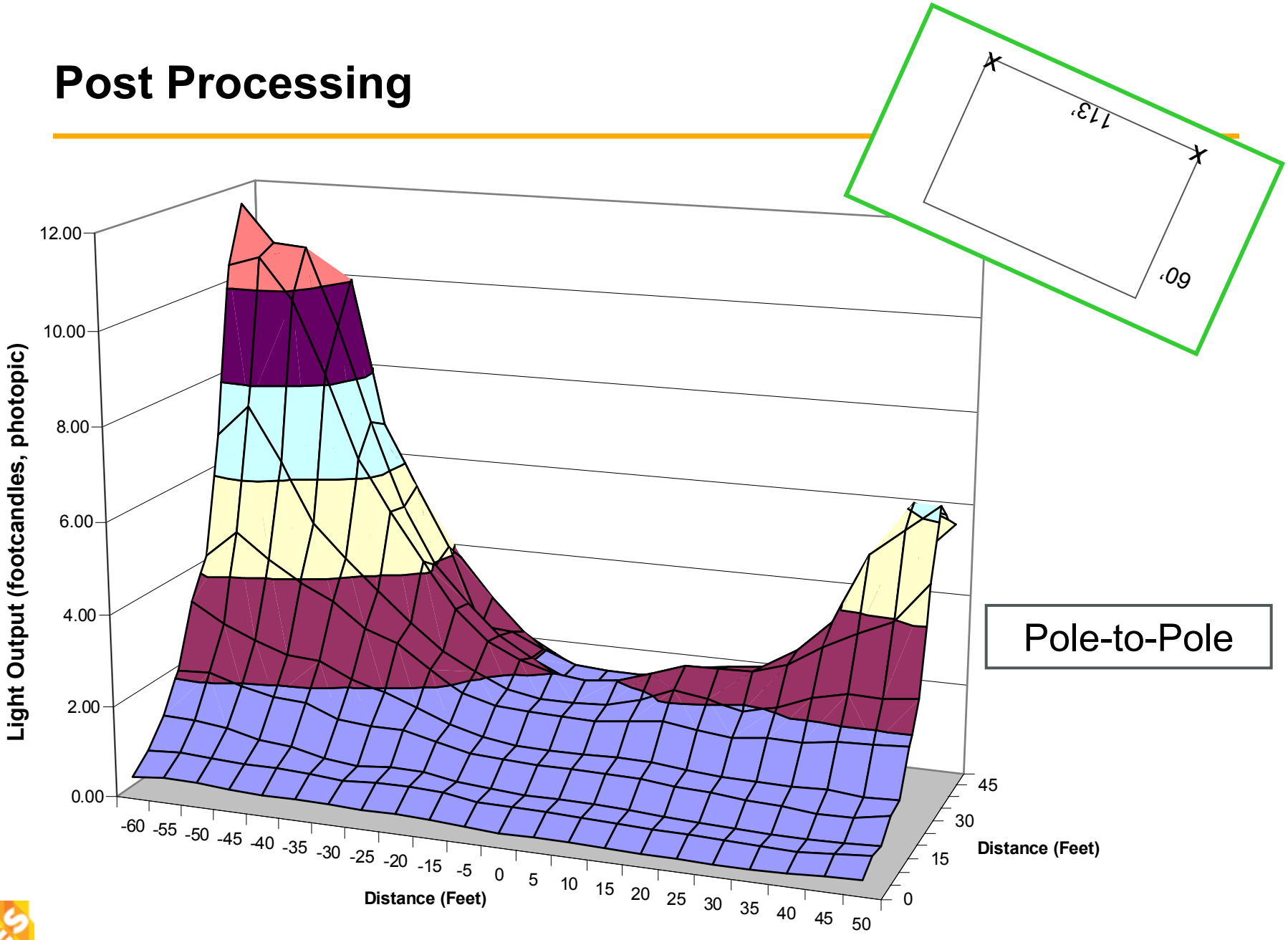


Pole-to-Pole

Benefits

Decrease measurement time while increasing the number of measurements

Increase grid resolution to two-feet square

Increase repeatability with sensor position determination to within a few centimeters

Increase safety by keeping test engineers out of roadways

For the first time, make practical the **measurement of efficacy on location** (Defined Area Efficacy)

Spot Measurements

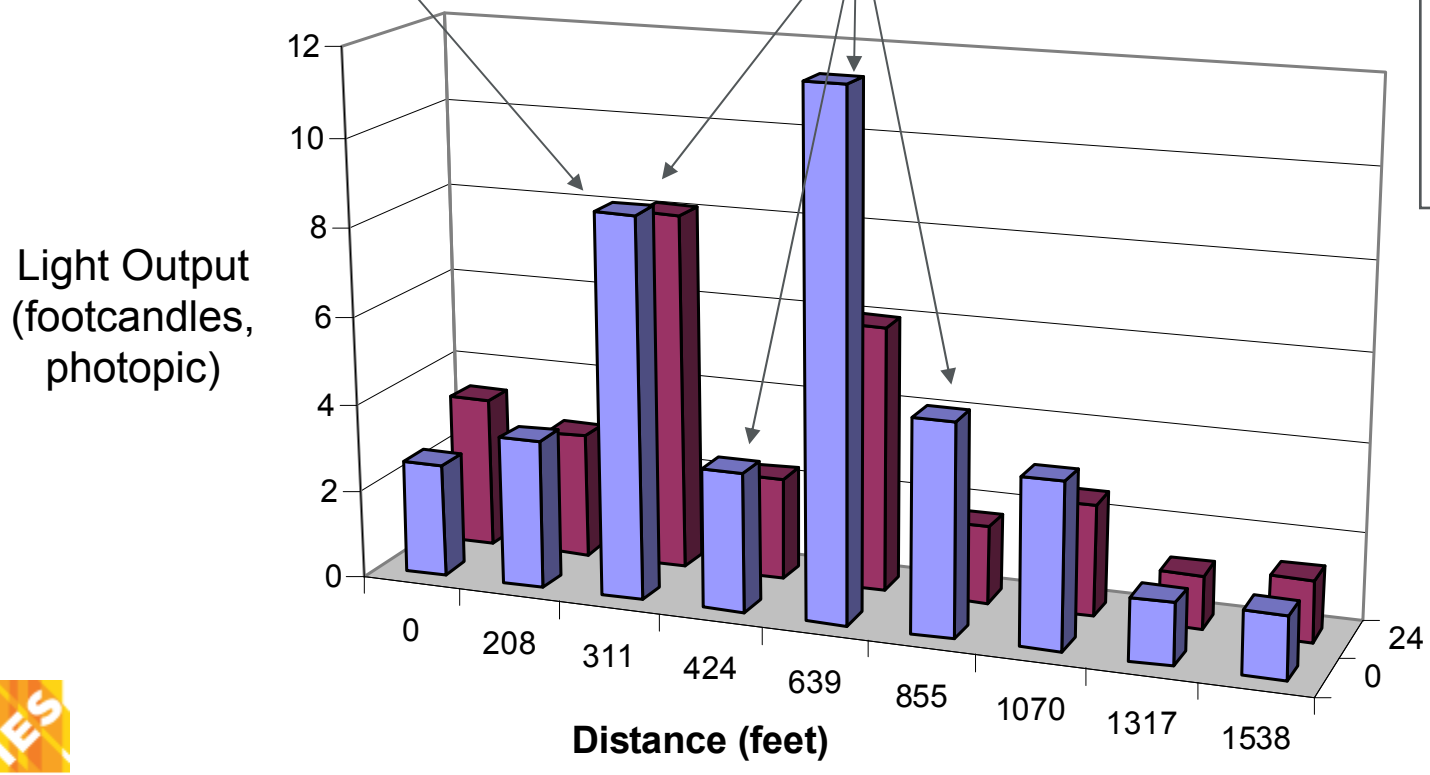
Photopic measurements over the length of the test area (south (0) to north(1538)). Measured on the sidewalk (blue) and in the middle of the street (approx. 24 feet, red).

Known new bulb (400 W)

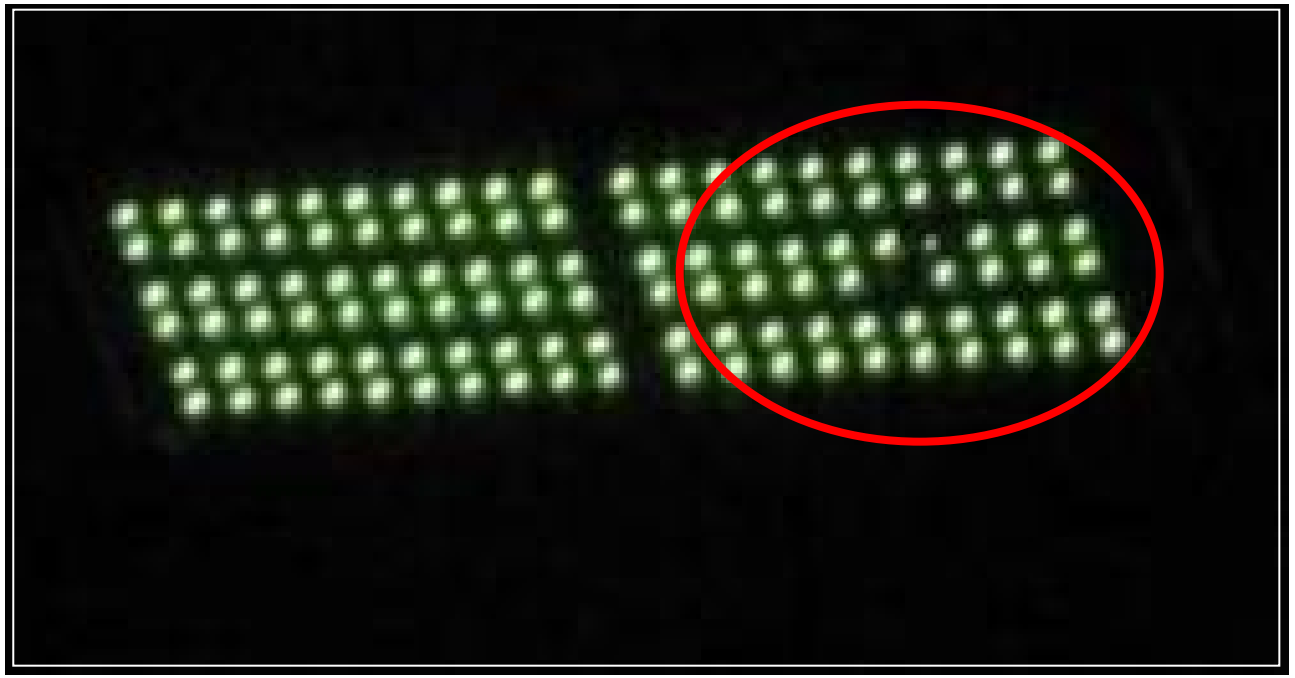
400 W, all others are 200 W

Reasons for the variation include:

-Bulb age
-Bulb wattage
-Fixture orientation



Failure of LEDs



Use welding goggles to detect failed LEDs.

What Will the Future Bring?

Today…

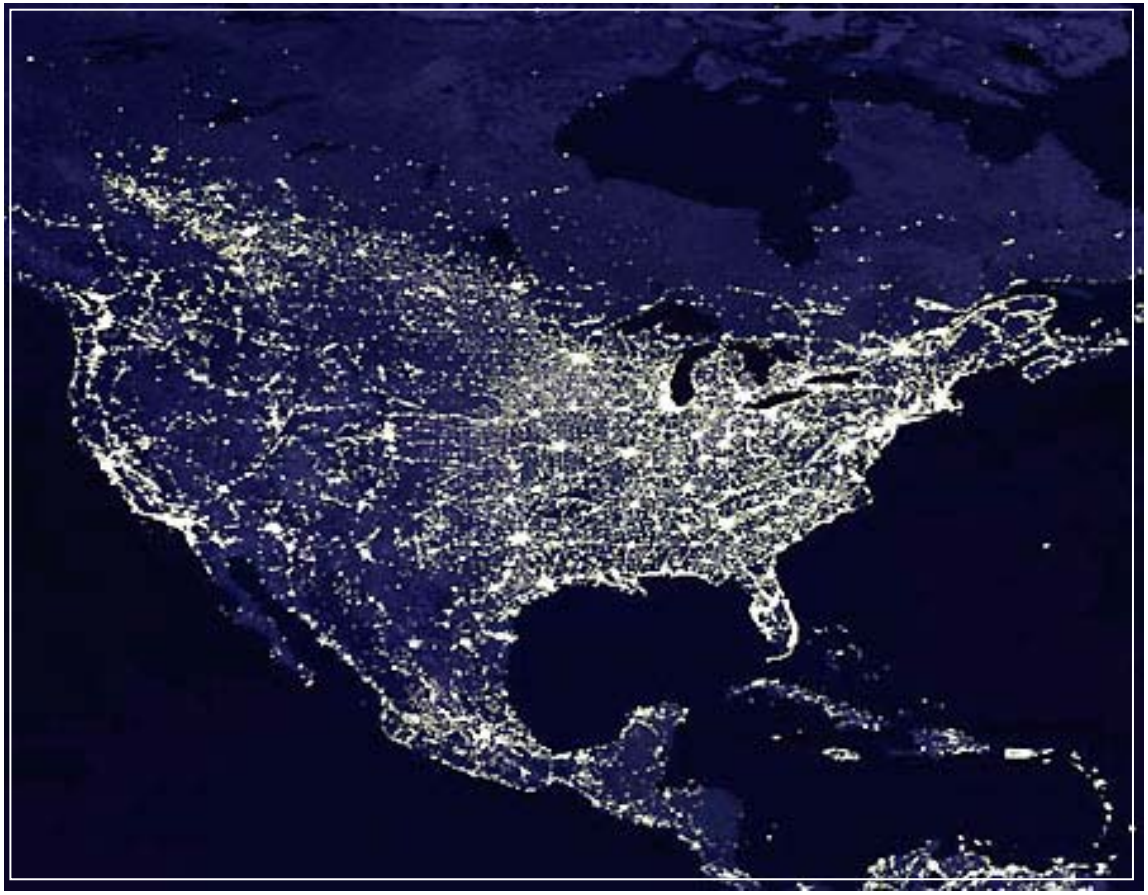
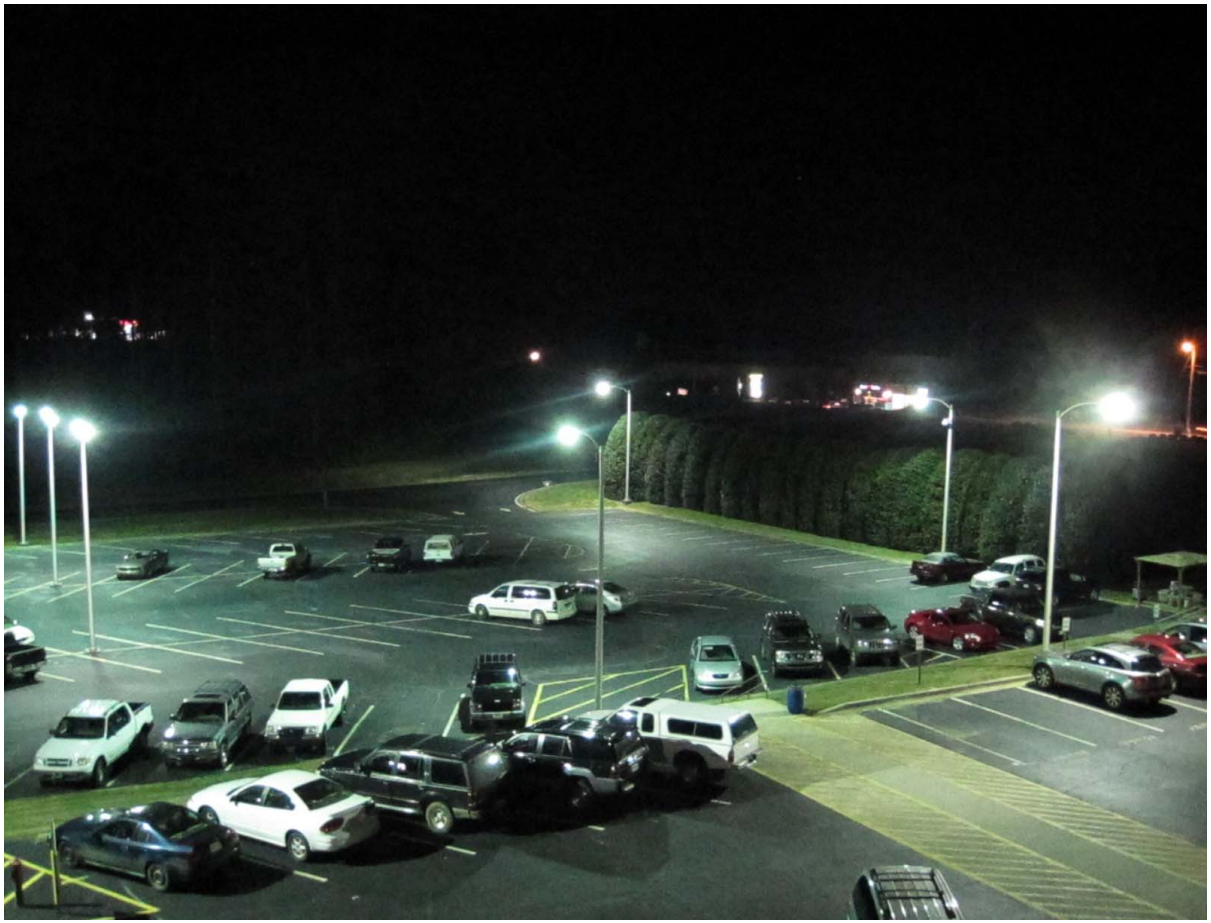


Image Credit: NASA/GSFC/Craig Mayhew and Robert Simmon

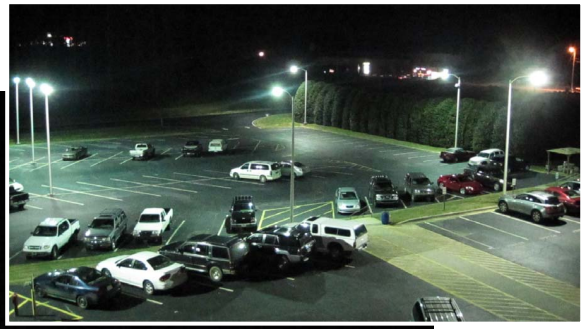
Southern Company – Georgia Power

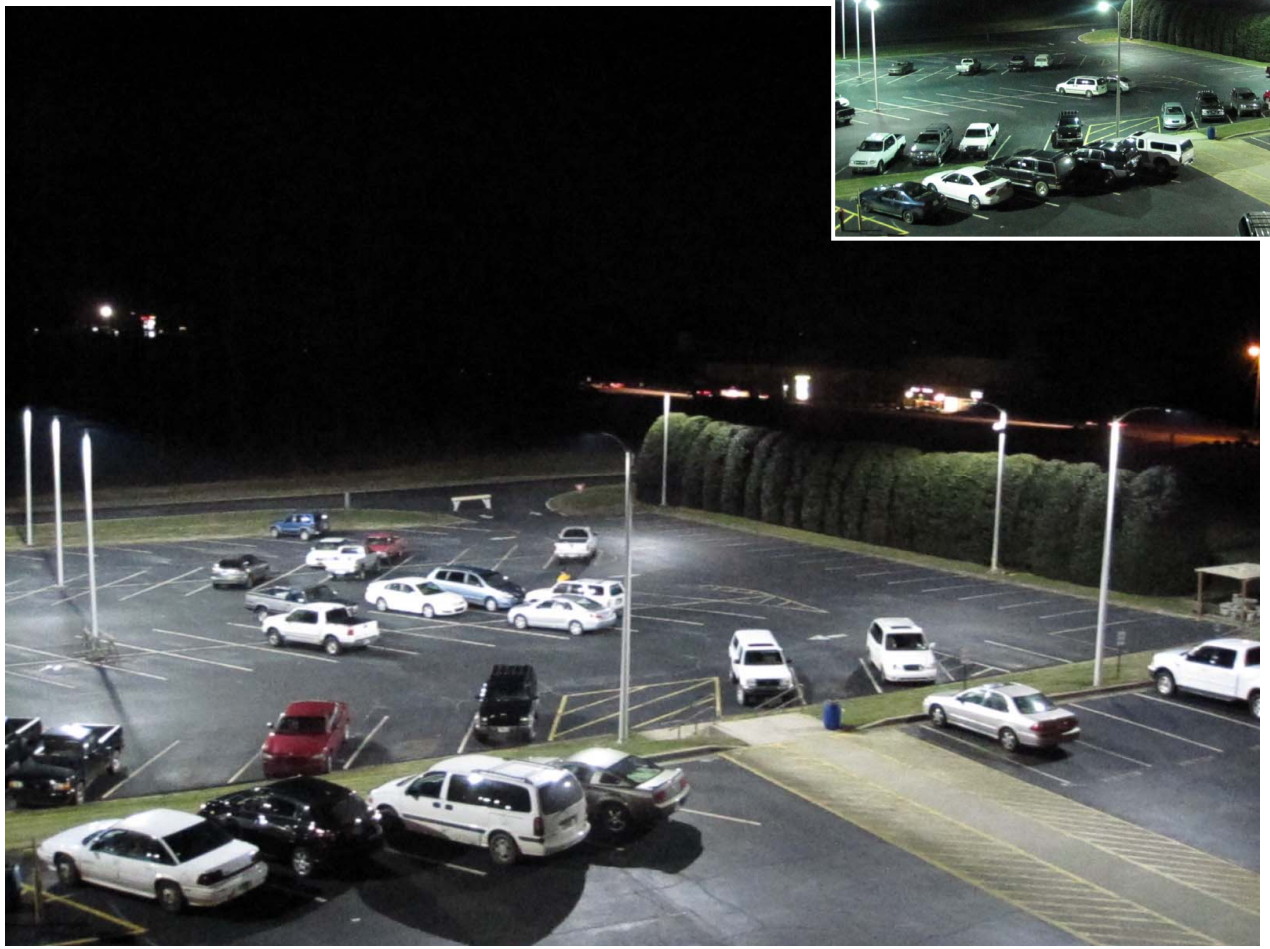
Before



Southern Company – Georgia Power

After





*Can you **see** the energy savings?*

TVA - Knoxville, TN

Before

310 W (each),
High Pressure Sodium (HPS)

After

94 Watt (each),
Light Emitting Diode (LED)

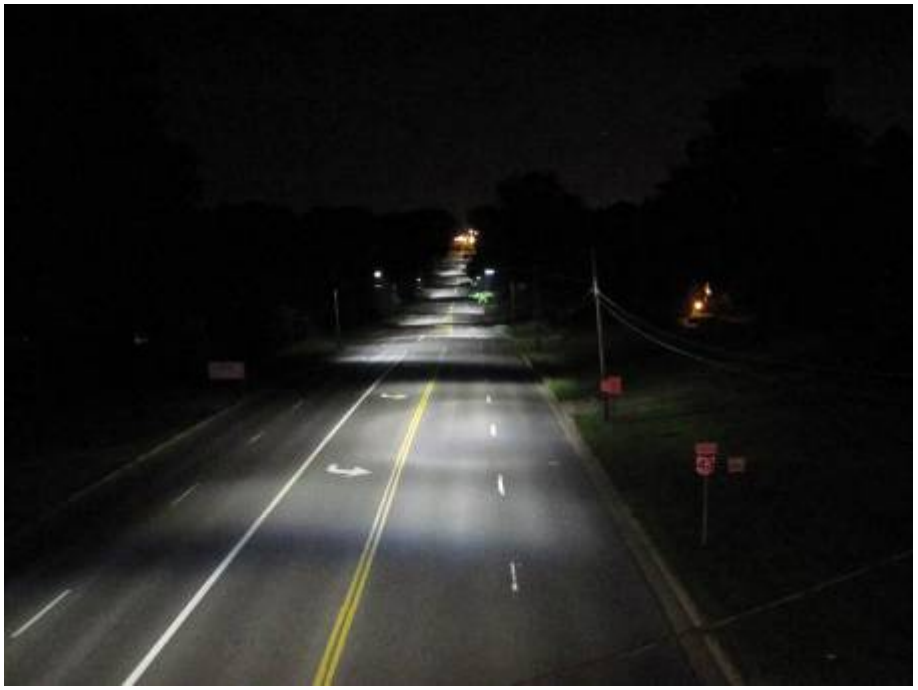
Disclaimer: Colors are approximate.

AEP – Canton, OH

Before

243 W Each, High Pressure Sodium (HPS) Measured Sample at AEP

After



187 W Each, Light Emitting Diode (LED) Average Measured Power of all 11 Fixtures

Disclaimer: Colors are approximate.

Central Hudson – Red Hook, NY

Before

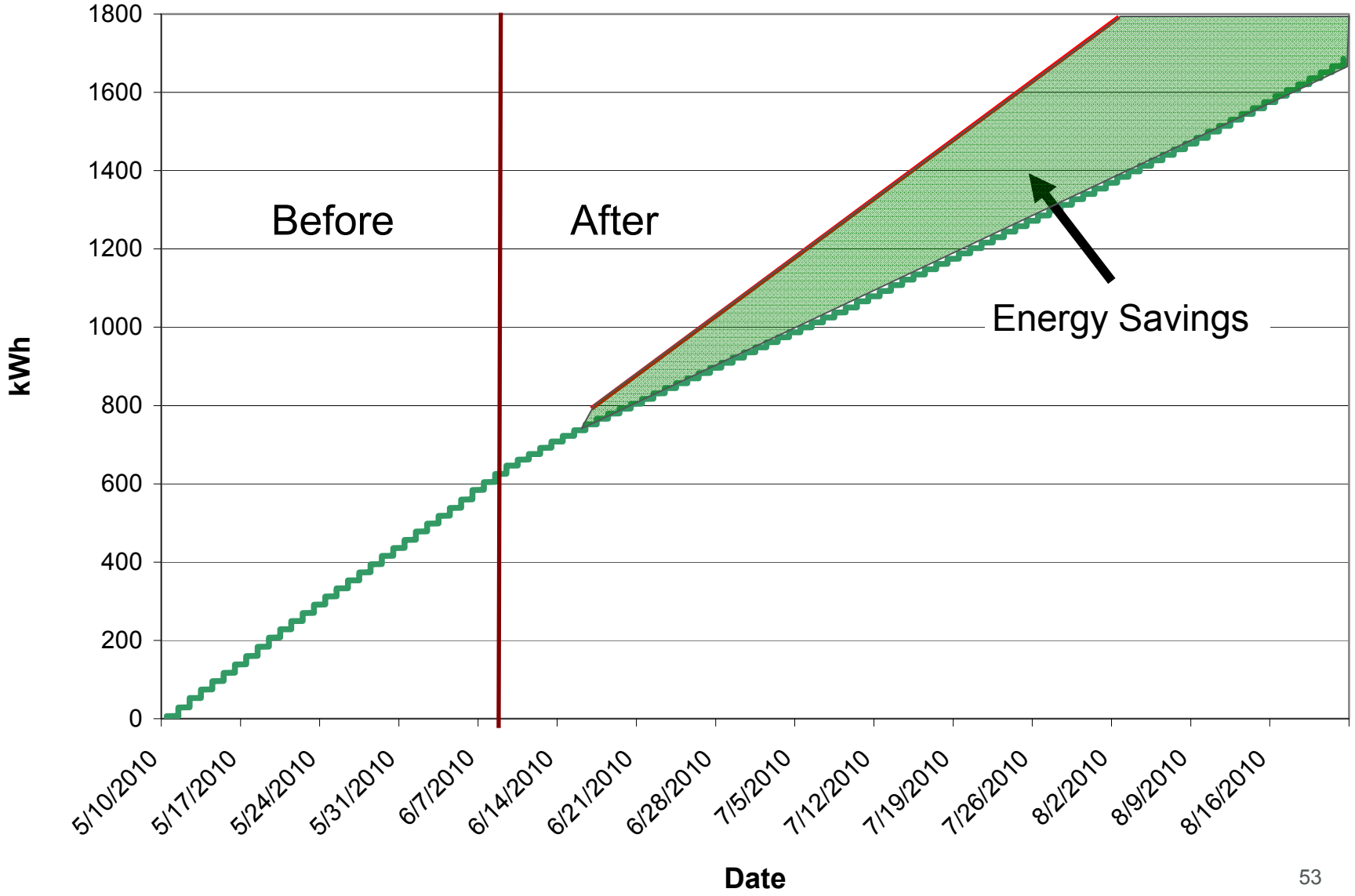
220 W Each, Metal Halide (MH), with cutoff collar

After

147 W Each, Light Emitting Diode (LED)

Disclaimer: Colors are approximate.

Energy Savings – Red Hook, NY



Lessons Learned 12 Months In…

Efficacy, quality of light, distribution of light and reliability are different than traditional options

LED fixtures are another tool used to fix a problem, which is how to illuminate an area. The only thing that is comparable is the lighting design

“Its not all on the side of the box”

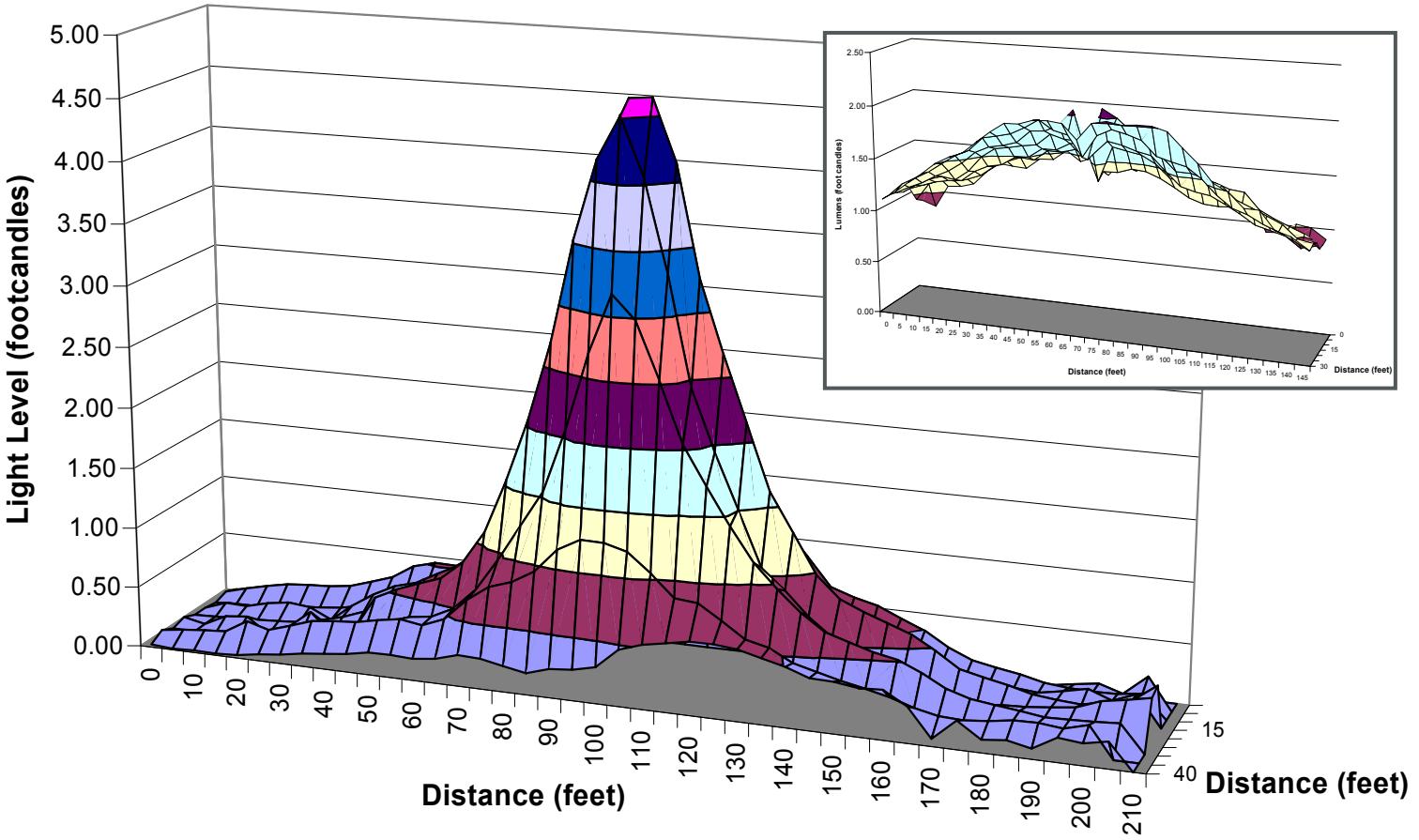
The danger is when the uninformed (utility or municipality) make a decision based on a single metric.

- Example, stereo wattage. 50 W versus 100 W. How about harmonic distortion?

The **good news** is that an LED fixture in some applications can provide acceptable illumination using less energy.

Distribution Differences

Rover measurements indicate that some manufacturers of LED fixtures have a cosine distribution while other do not. **Why?**

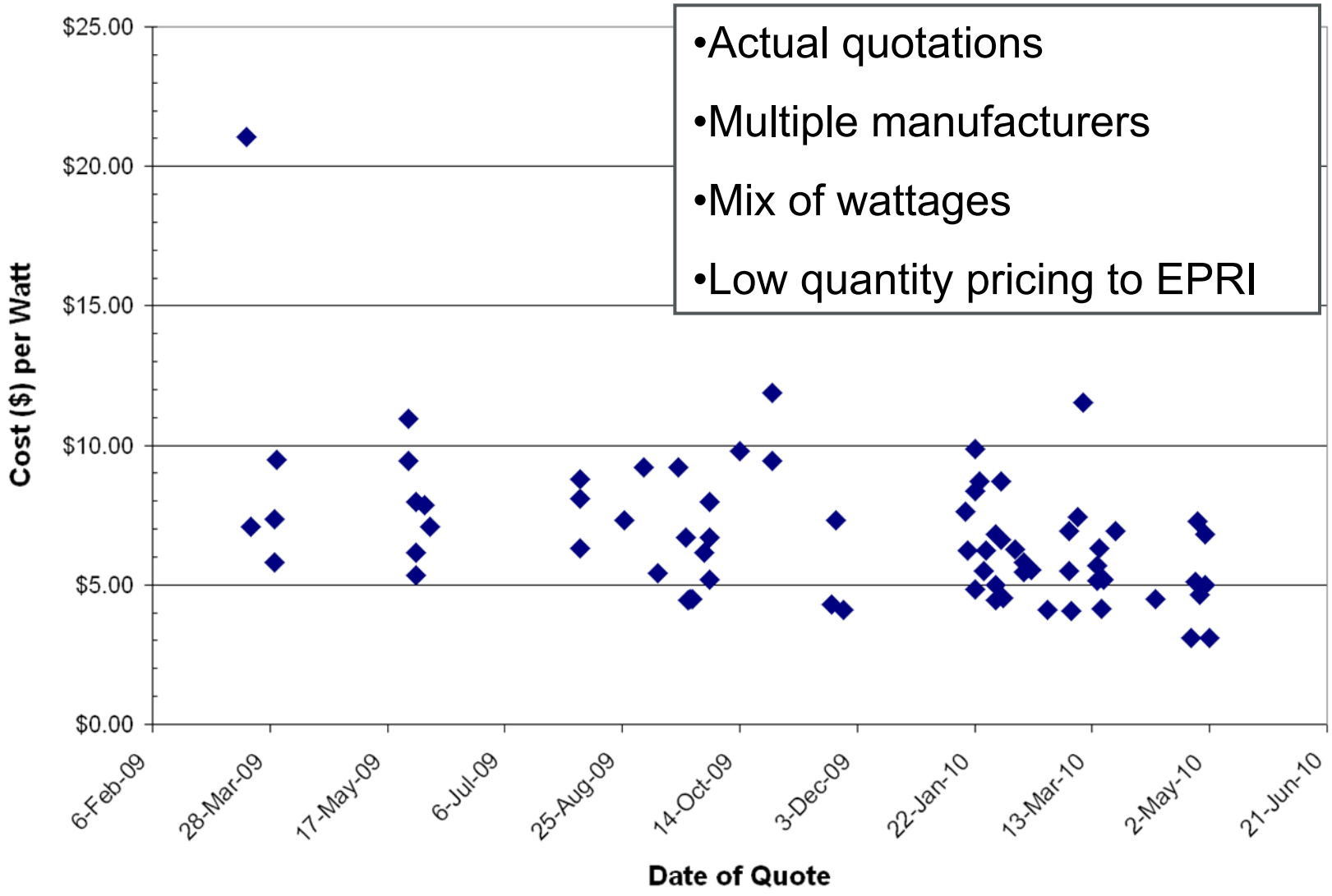


On Pricing

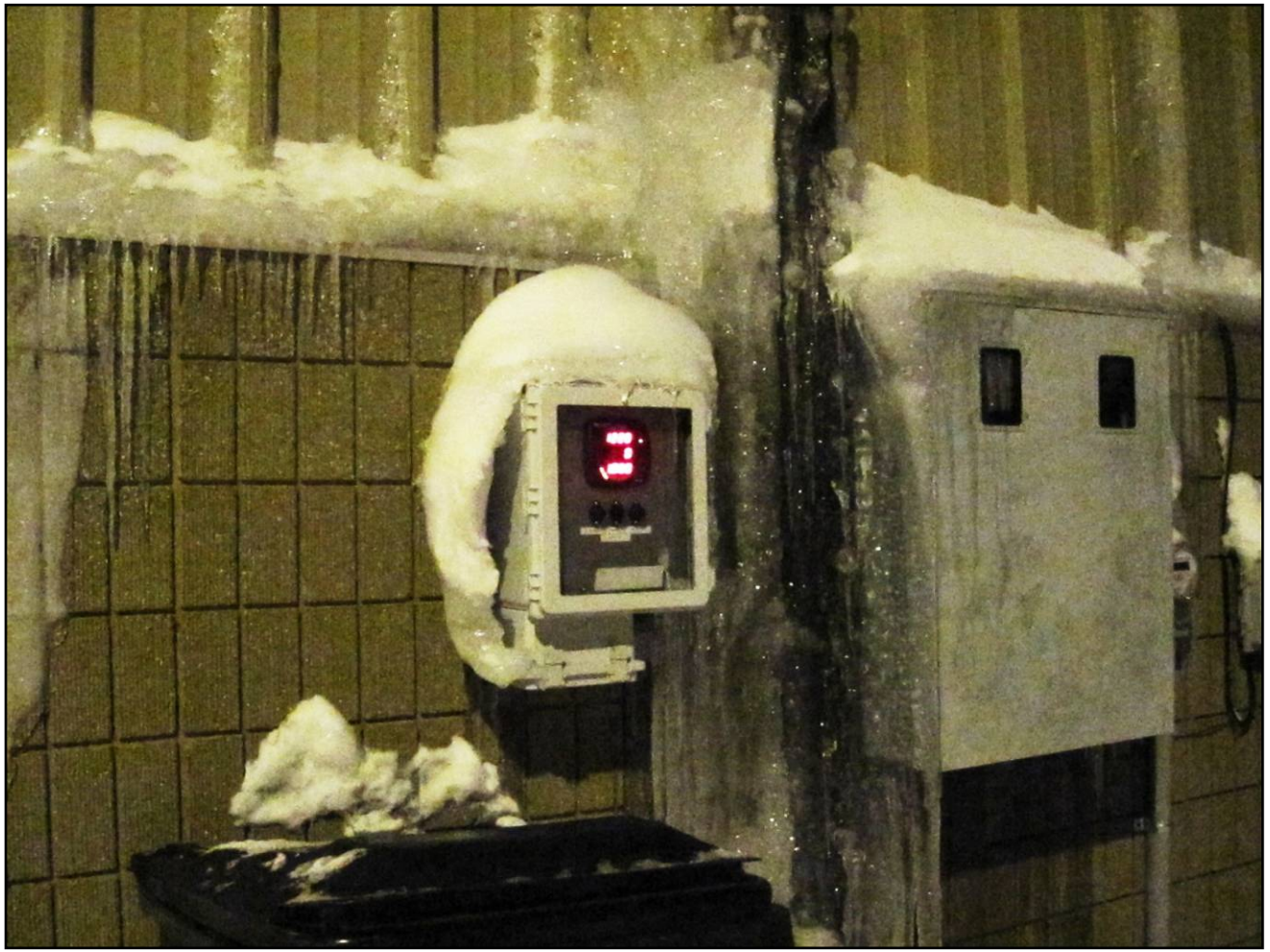
Many people don’t know that…

The energy portion of a lighting bill is only a small fraction of the total.

Trending in the Right Direction



Field Work is Tough…



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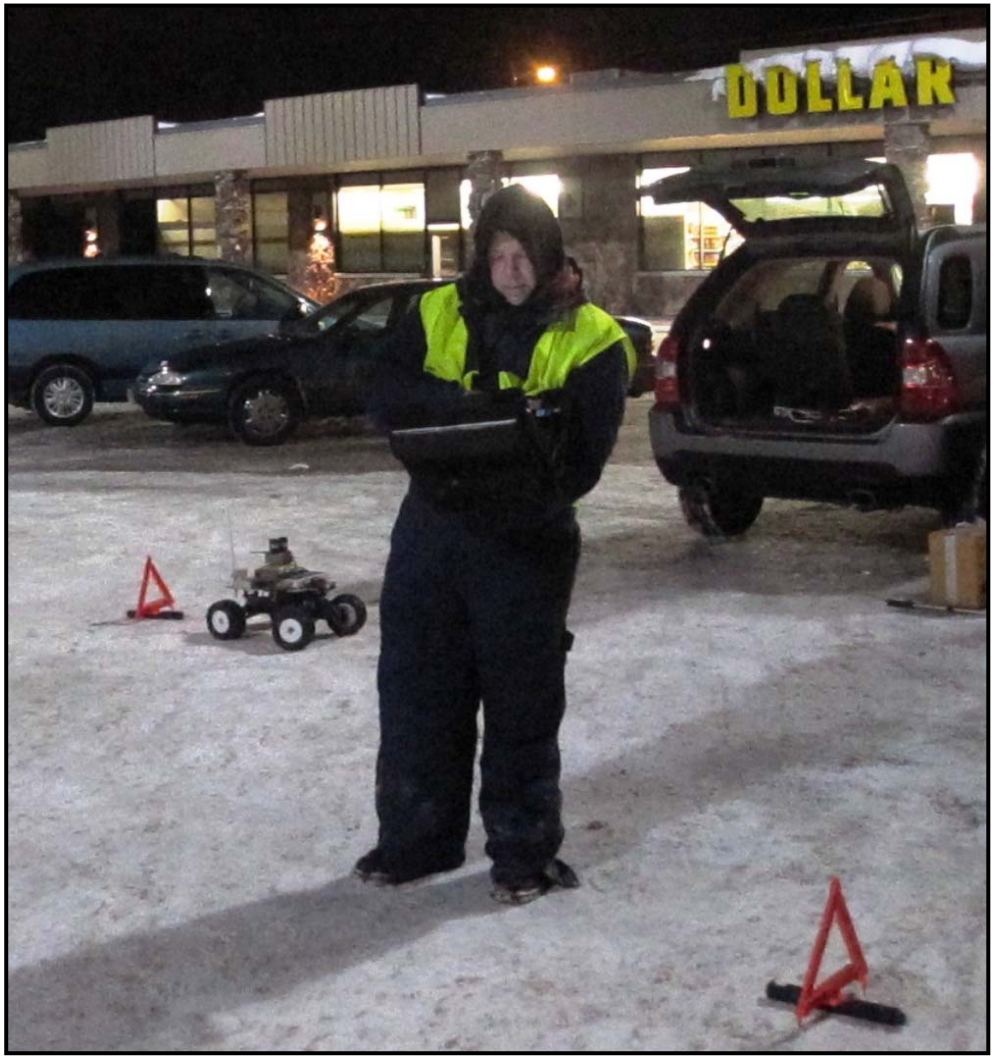

Summary

Remember

LEDs are part of the solution to a big problem

The ultimate test of any technology is if it will work in the field

Lighting involves the human eye. Humans are complex. Therefore lighting is complex.

You don't know until you measure… ***Let's all measure***.

> ***"For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled."***
>
> *- Richard Feynman*

Closing Thought…

"It would appear that we have reached the limits of what it is possible to achieve with computer technology, although one should be careful with such statements, as they tend to sound pretty silly in 5 years."

– John Von Neumann (ca. 1949)

Anything is Possible…

Together…Shaping the Future of Electricity