



2016

SAVE THE DATE

BETTER BUILDINGS SUMMIT

WASHINGTON, DC ■ MAY 9-11



U.S. DEPARTMENT OF
ENERGY

<http://www1.eere.energy.gov/buildings/betterbuildings/summit/>

U.S. DEPARTMENT OF
ENERGY



Lessons Learned from Outdoor Connected Lighting System Installations

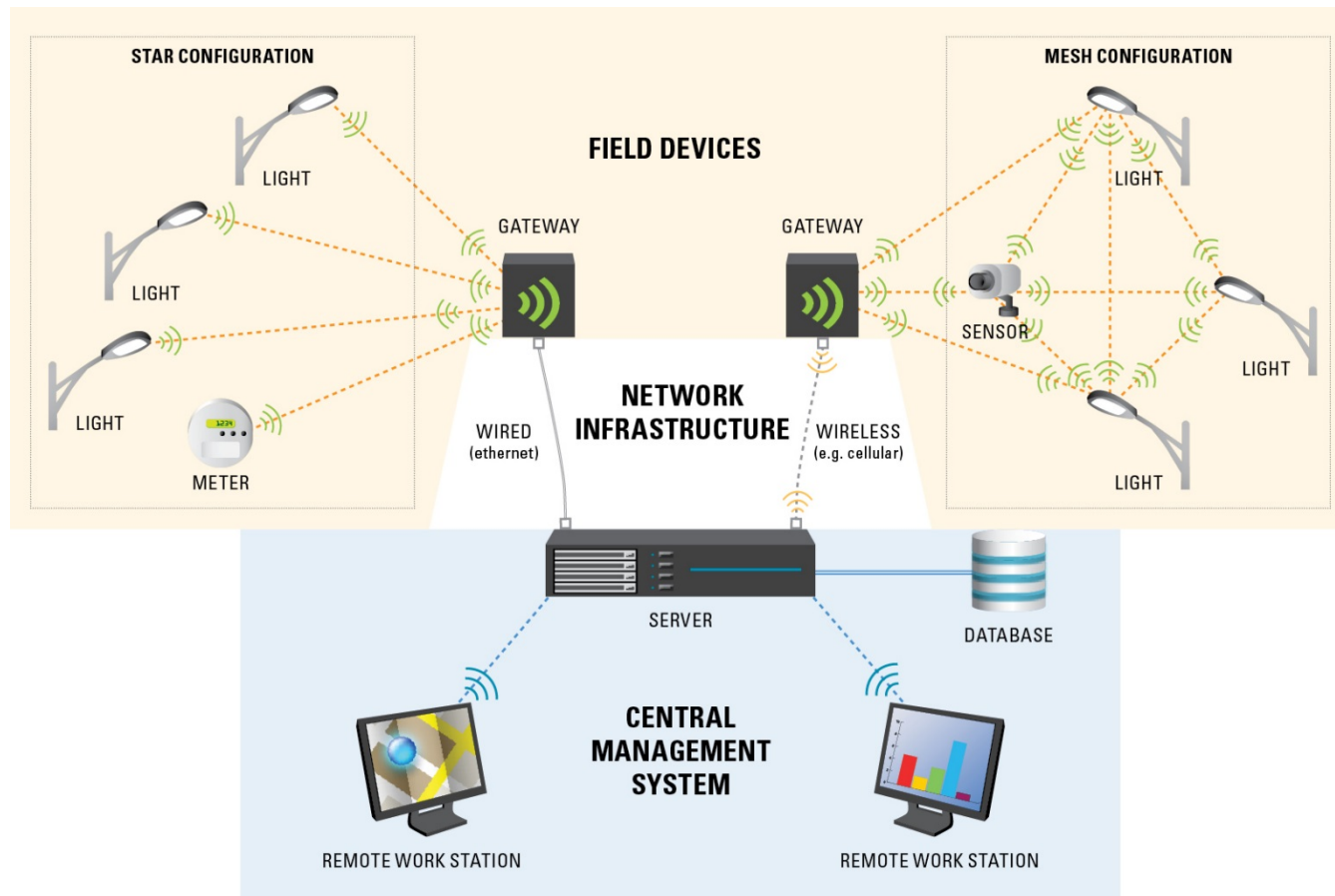
January 12, 2016

Michael Poplawski, Pacific Northwest National Laboratory

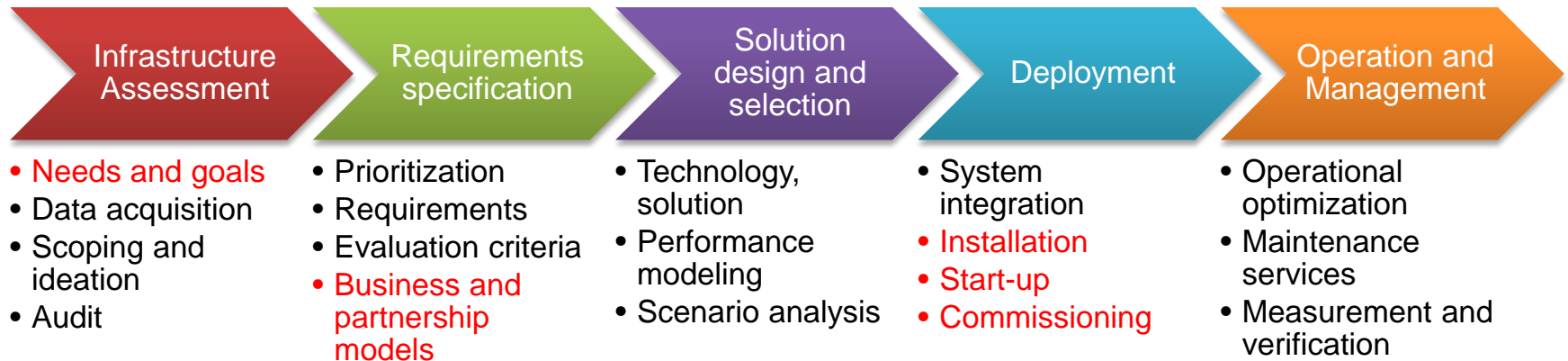
Outline

- Introduction
 - What is a networked outdoor lighting control system?
 - Who is interested in them, and why?
- Utility tariffs
- Lighting system ownership
- Installation, start-up, and commissioning
- Some future possibilities and challenges

A networked outdoor lighting control system



Systems are more complicated than devices



Value Propositions



Maintenance

Adaptive Lighting,
Environment

Maintenance

Adaptive Lighting
(CLO)

Adaptive Lighting,
Still Searching

Adaptive Lighting,
Still Searching

Value Propositions



Tuning,
Adaptive Lighting



Maintenance,
Customer Satisfaction



Asset Management



Security,
Still Searching



AMI,
Maintenance

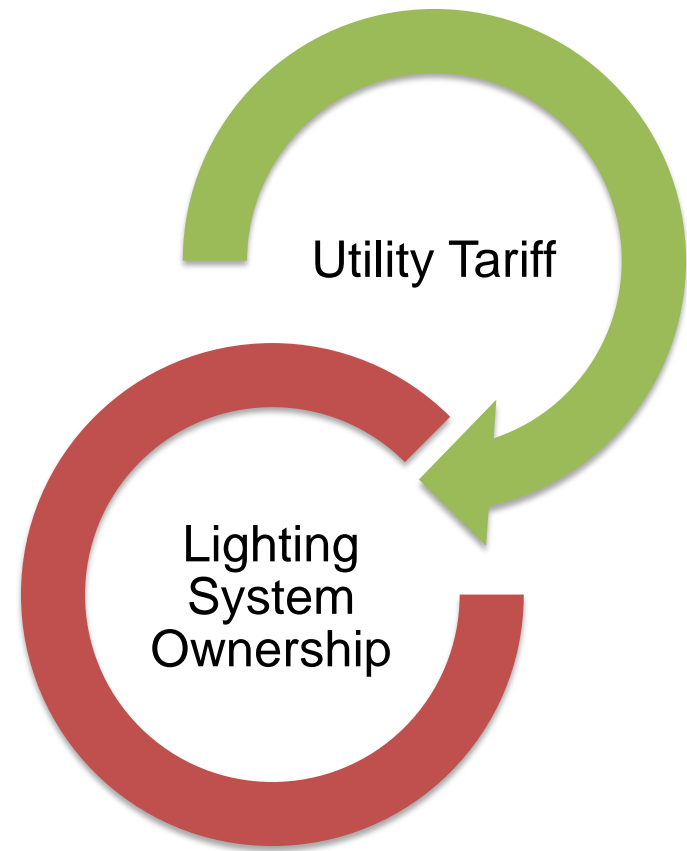
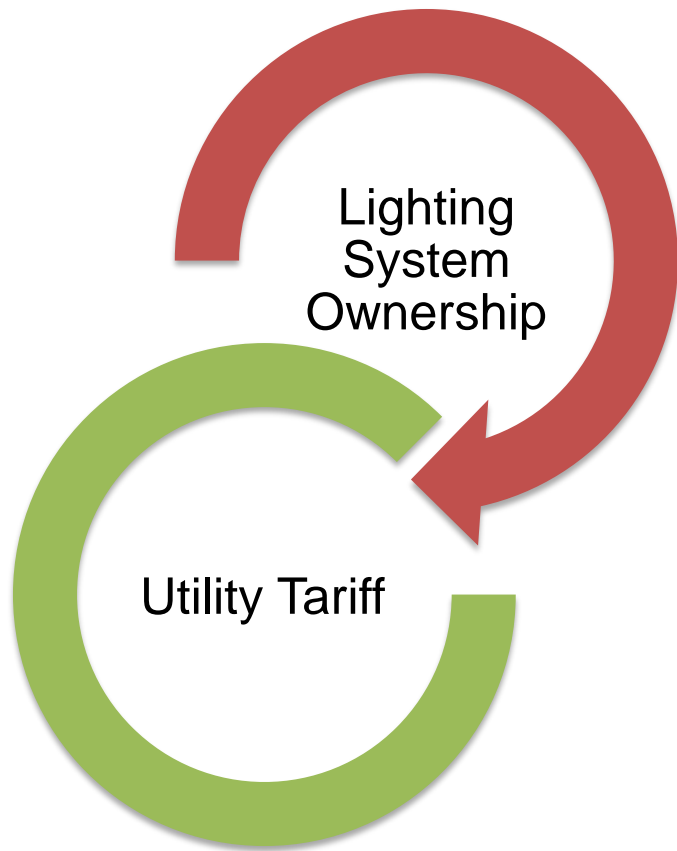


Environment

Cost and Impact

- Operational Costs
 - Maintenance
 - Identifying failures
 - Replacement: components + labor
 - Energy
 - Mostly unmetered
 - Estimates: Operating hours x power x energy price
- Energy & Sustainability Impact
 - kWh/year consumed
 - CO₂ impact: 6.89551×10^{-4} metric tons CO₂ / kWh

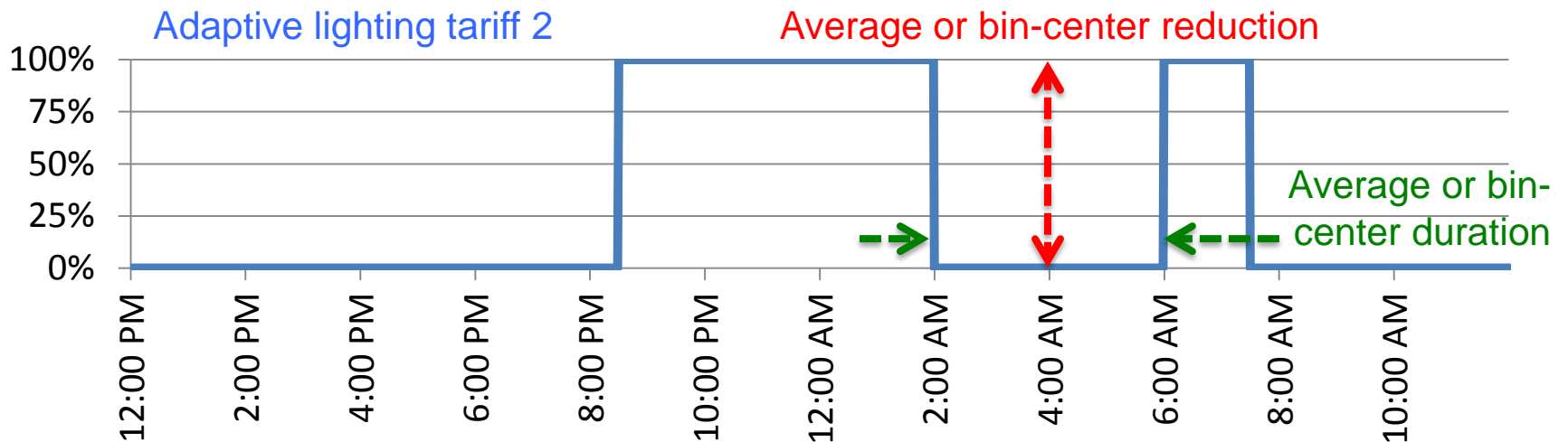
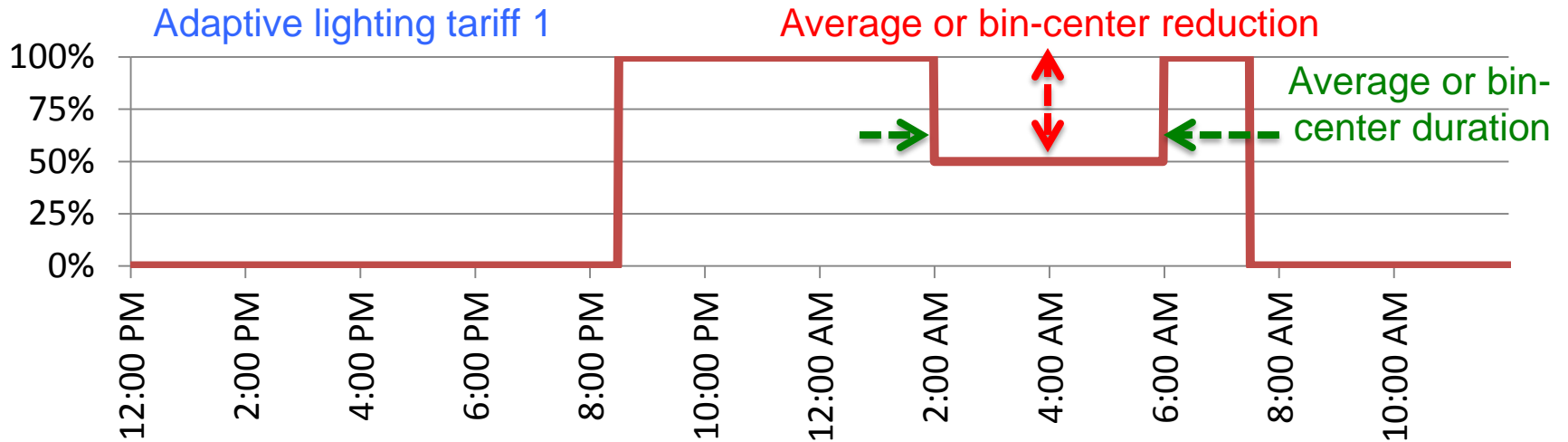
What comes first?



Monetizing Energy Savings

- Requires new utility tariff(s)
- Existing utility infrastructure does not support accepting metering data
- Existing metering standards not (directly) applicable
 - ANSI C12.1, 12.20
 - Meter accuracy
 - Data security for billing purposes
- New ANSI C136.50 “revenue grade energy measurement device” standard (specific for lighting) under development

Alternatives to Energy Metering



Utility Tariffs

Tariff Type	Energy Use Determination
Flat	Calculated (fixed or variable output) [\$/kWh/light per month]
Fixed Energy	Metered (utility owned meter) [\$/kWh/light + meter charge per month]
Time-of-Use Energy	Metered (utility or customer owned meter) [Variable \$/kWh/light per month]

Utility Tariffs

BC Hydro
Flat,
Variable Output

PG&E
Flat, Fixed Output vs.
Fixed Energy

SDGE
Fixed Energy
A Sempra Energy utility®

Xcel EnergySM
Flat,
Variable Output

GEORGIA POWER
Time of Use Energy
A SOUTHERN COMPANY

NV Energy
Flat,
Fixed Output

Flat, Fixed Output Tariff Example

RATES:

The total monthly charge per lamp is equal to the sum of the facility charge and the energy charge. The monthly charge per lamp used for billing is calculated using unrounded facility and energy charges.

Monthly facility charges include the costs of owning, operating and maintaining the various lamp types and size. Monthly energy charges are based on the kWh usage of each lamp.

Monthly energy charges per lamp are calculated using the following formula: (Lamp wattage + ballast wattage) x 4,100 hours/12 months/1000 x streetlight energy rate per kilowatt hour (kWh). Ballast wattage = ballast factor x lamp wattage.

SPECIAL CONDITIONS: (Cont'd.)

- 7. OPERATING SCHEDULES OTHER THAN ALL-NIGHT:** Rates for regular operating schedules other than full all-night will be the AN rate, plus or minus, respectively, the half-hour adjustment for each half-hour more or less than an average of 11 hours per night. This adjustment will apply only to lamps on regular operating schedules of not less than 1,095 hours per year, or 3 hours per night, and may be applied for 24-hour operation. Photo control devices used for more or less than AN must be approved by PG&E prior to adjustments in billing.

(L)
|
|
|
|
|
|

Flat, Variable Output Tariff Example

MONTHLY RATE

The Monthly Energy Range and rate shall be determined by Company as set forth in the Kilowatt-hour Use Determination section.

Monthly Energy Range, kWh per light:	<u>REF NO.</u>	
0.0 – 3.0	001	\$ 0.07
3.1 – 6.0	002	0.20
6.1 – 9.0	003	0.34
9.1 – 12.0	004	0.47

MONTHLY RATE – Cont'd

Monthly Energy Range, kWh per light:	<u>REF NO.</u>	
132.1 – 135.0	045	\$ 6.03
135.1 – 138.0	046	6.16
138.1 – 141.0	047	6.30
141.1 – 144.0	048	6.44
144.1 – 147.0	049	6.57
147.1 – 150.0	050	6.71
150.1 – 153.0	051	6.84
153.1 – 156.0	052	6.97

Flat, Variable Output Tariff Example

Kilowatt-Hour Use Determination

- Lamp type
- Size
- Ballast
- Light control device
- Number of lamps or groups of lamps or lighting components
- Hours of operation (burning Hours),
- Dimming schedule together with the reduced wattage during such dimming hours.

Monitoring

- Temporary meter
- Sampling program
- Periodic testing

$\text{kWh/light per month} = \text{total annual kilowatt-hours of usage}/12$

Time-of-Use Energy Tariff Example

Existing (HPS)

- Photo-controlled: 4.8315¢ per kWh
 - Dusk to dawn Mon-Sun for all calendar months
- Continuous Burn: 5.5270¢ per kWh
 - 24 hours a day Mon-Sun for all calendar months
- Part Night
 - Dimmed or off for some period each night
 - Rate somewhere in between the photo-controlled and continuous burn

New (LED)

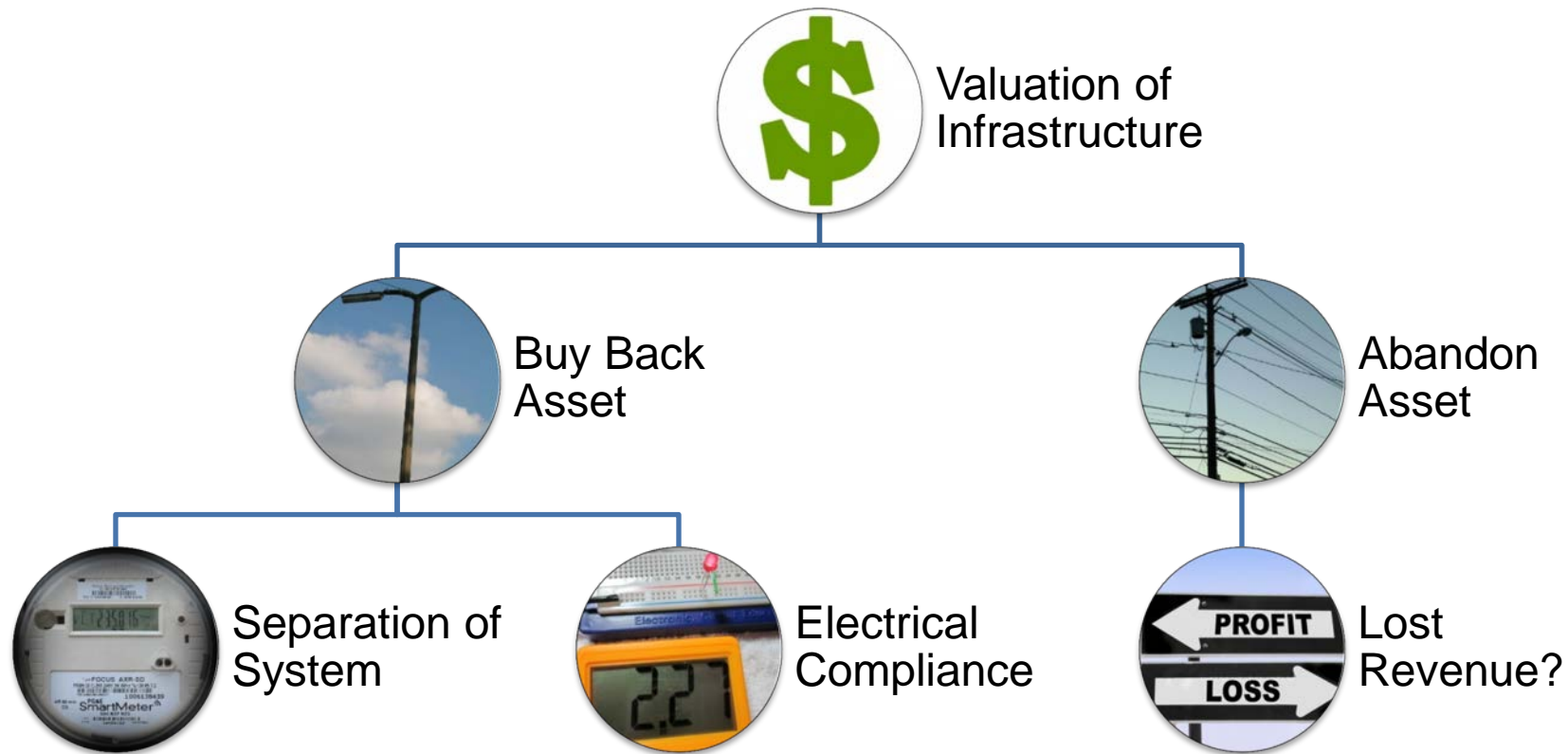
- Super Off-Peak: 3.3225¢ per kWh
 - 11:00 PM–7:00 AM, Mon-Sun for all calendar months
- Off-Peak: 8.1538¢ per kWh
 - Weekends, holidays and any day in Oct–May: 7:00 AM–11:00 PM
 - June–Sept (Mon–Fri): 7:00 AM–2:00 PM & 7:00 PM– 11:00 PM
- On-Peak: 9.4595¢ per kWh
 - 2:00 PM–7:00 PM, Mon–Fri, June–Sept (Summer)
 - Excludes Independence Day and Labor Day

Lighting System Ownership

- Where to start?
- Where is the line of demarcation?
- Electrical system in compliance?
 - NESC vs. NEC



Lighting System Ownership



<http://www.mapc.org/system/files/bids/Buy%20Back%20Streetlights%20from%20Utility.pdf>

System Configuration

Installation

Devices have basic necessities for operating as intended

- Luminaire integration
- Input voltage
- Wiring configuration
- Sensor integration
- Ancillary devices

Start-up

Devices are operating as intended, all system functions and capabilities are available to the user

- Lighting control protocol
- Electromagnetic immunity (EMI)
- Network architecture
- Wireless spectrum
- Backhaul availability
- Security

Commissioning

System functions and capabilities are configured according to user desires

- Location
- Grouping
- Scheduling
- Real-time monitoring
- Sensor algorithms
- Adaptive Lighting
- Command Prioritization

Luminaire Integration Options

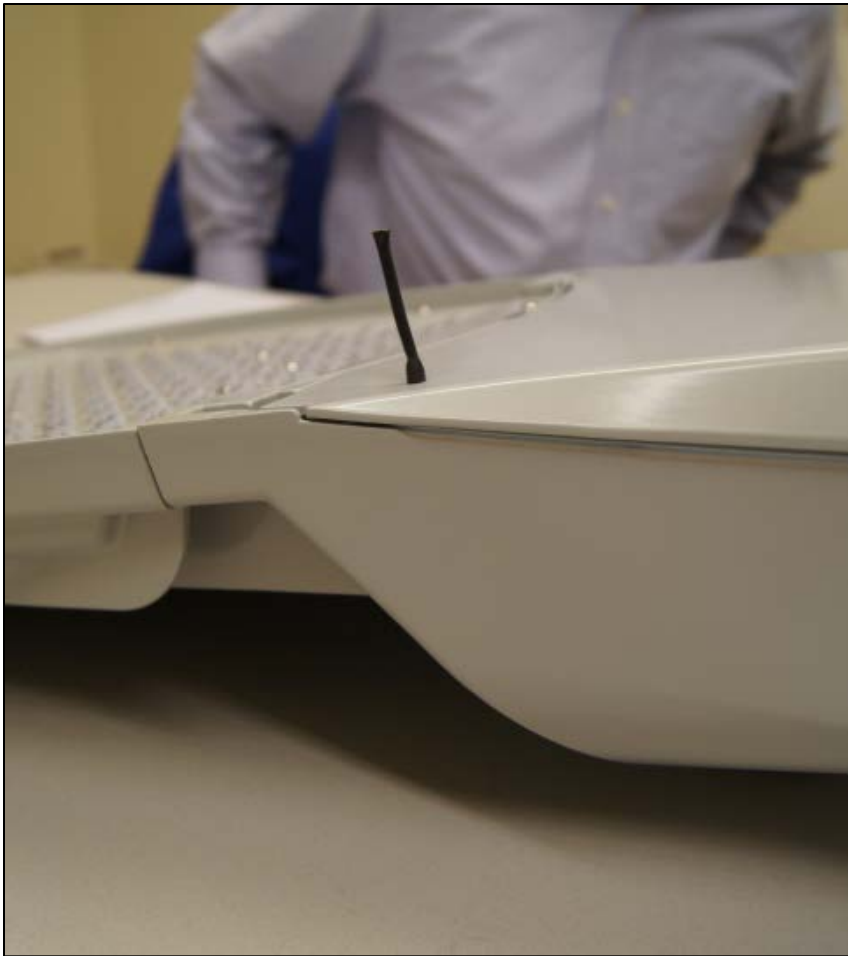
- External to luminaire, fixed output (on/off only)
 - 3-prong receptacle (ANSI C136.10)
 - 5-7 prong receptacle (ANSI C136.41)
- External to luminaire, variable output
 - 3-prong receptacle (ANSI C136.10) + wired solution
 - 3-prong receptacle (ANSI C136.10) + power-line carrier (PLC) solution
 - 3-prong receptacle (ANSI C136.10) + wireless solution
 - 5-7 prong receptacle (ANSI C136.41)
- Internal to luminaire
 - Installation, responsibility
 - LED driver interaction (heat, unintentional radiation)
 - Antenna
- Integral to luminaire (i.e. internal to ballast/driver)

Luminaire Integration Options



- Internal to luminaire (today)
- Integral to luminaire i.e. internal to the ballast/driver (soon)

Luminaire Integration Lessons



Input Voltage Options

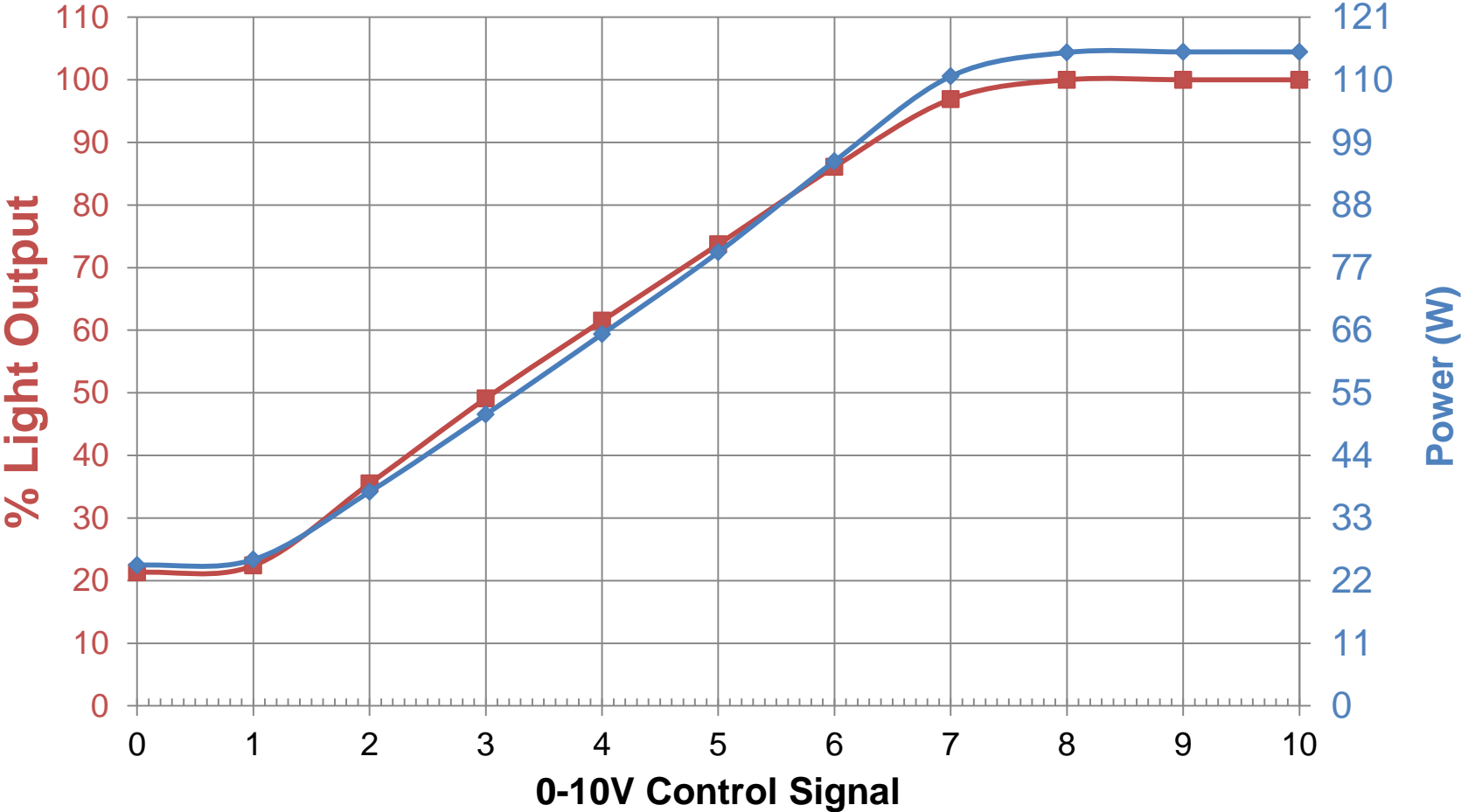
- Universal (120 – 277 Volt)
- 240 Volt
- 347 Volt
- 480 Volt
- Internal (to luminaire) transformers required for high(er) voltage luminaires if suitable controller is not available
- Emerging options powered by driver/ballast

Vendor	120 Volt	240 Volt	277 Volt	120 – 277 Volt	347 Volt	480 Volt
A				X	X	X
B				X	X	X
C				X		S
D				X		
E				X		
F				X		
G		X				
H		X				

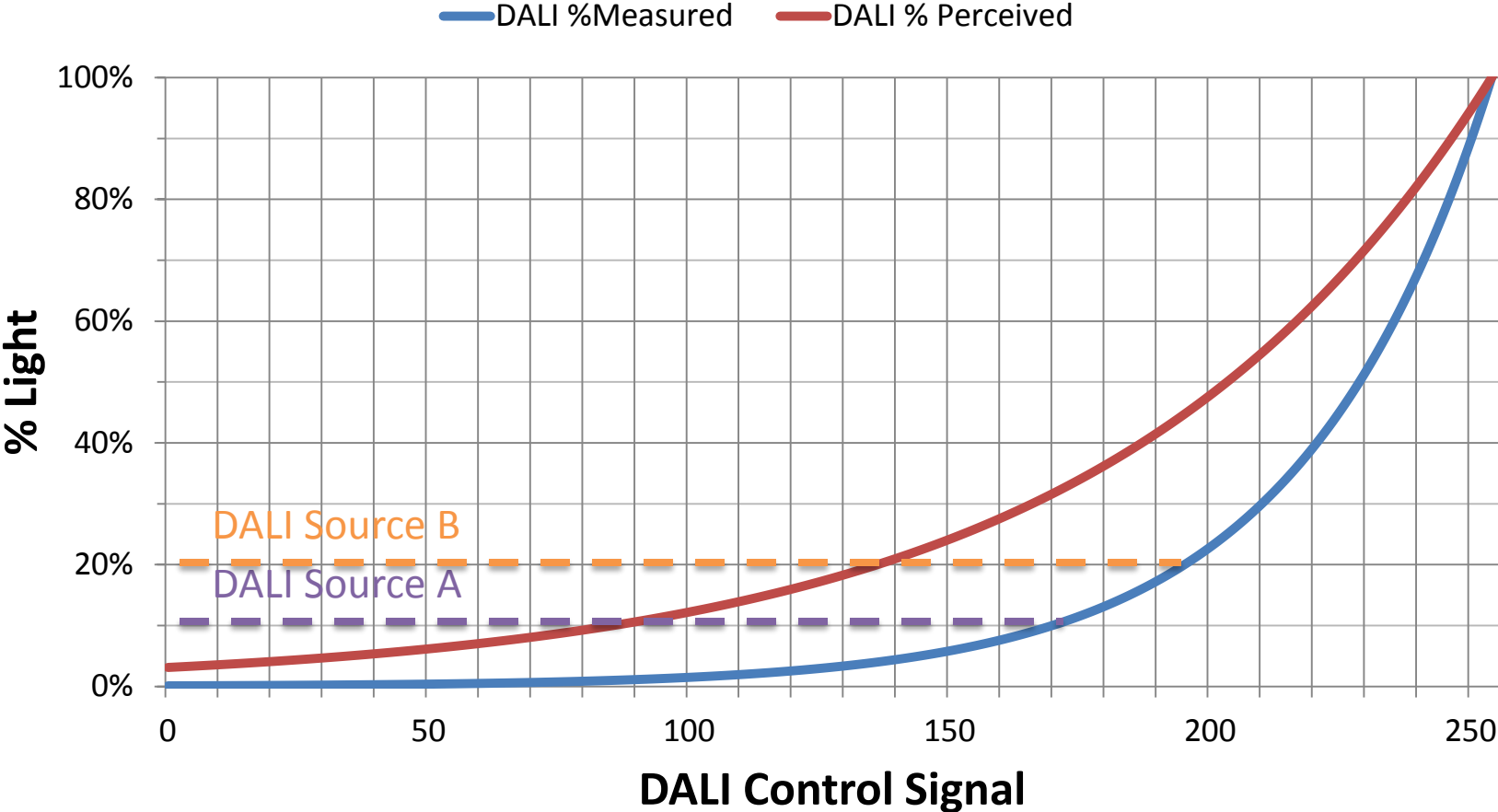
Lighting Control Protocol Options

- 0-10V
 - One-way analog communication with driver/ballast
 - Can not set power or light level
- DALI
 - Two-way digital communication with driver/ballast
 - Can set light level
 - Can (theoretically) extract luminaire, driver/ballast characteristics (e.g. make/model, power profile)
 - Can report driver/ballast characteristics (e.g. temperature)
- Integral to luminaire driver/ballast

Example 0-10V Dimming Curve



Standardized DALI Dimming Curve



Location Commissioning Options

- No capability
- Controller location is assigned from an existing database
- Controller location is captured using a field commissioning device (with GPS)
- Controller captures its own location (via integral GPS)

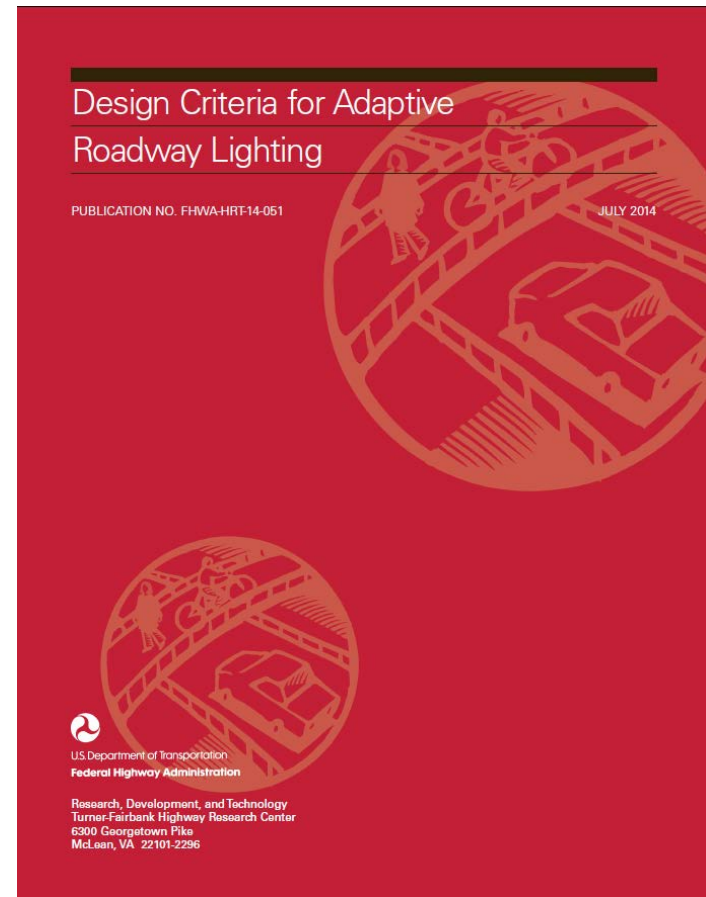


Location Commissioning Lessons



Some Future Possibilities & Challenges

- Adaptive lighting
- Non-energy benefits
- Distributed Intelligence, Big Data, Analytics, Cloud Computing
- Security
- Public relations



<http://www.fhwa.dot.gov/publications/research/safety/14050/14050.pdf>

Application of Adaptive Lighting

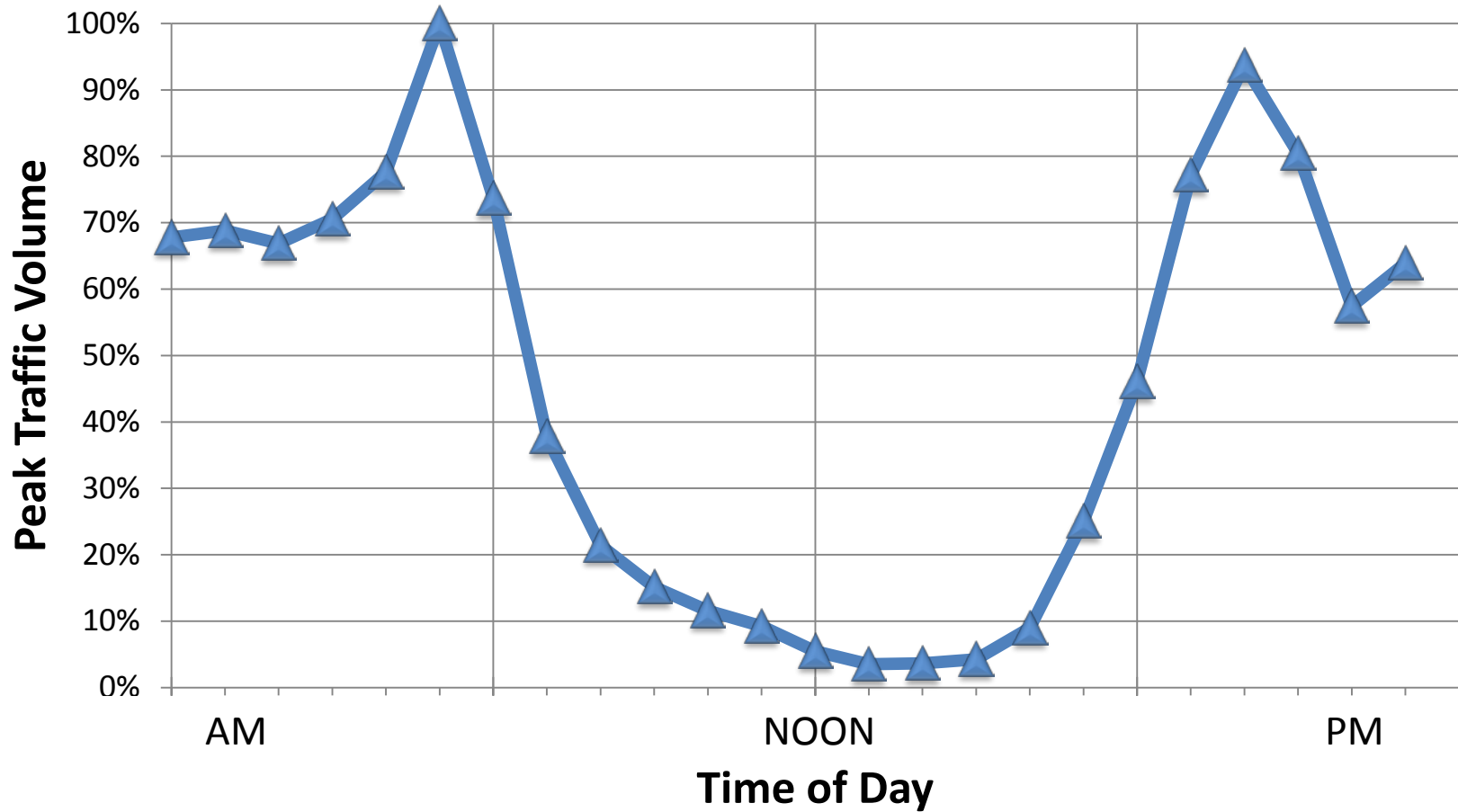
Parameter	Options	Criteria	Weighting Value
Speed	High	> 45 mi/h (70 km/h)	1
	Moderate	35–45 mi/h (55–70 km/h)	0.5
	Low	< 35 mi/h (55 km/h)	0
Traffic Volume	High	> 15,000 ADT	1
	Moderate	5,000–15,000 ADT	0
	Low	< 5,000 ADT	-1
Median	No	No median present	1
	Yes (or one-way)	Must be glare blocking	0
Intersection/ Interchange Density	High	> 5 per mi (1.6 km)	1
	Moderate	1–5 per mi (1.6 km)	0
	Low	< 1 per mi (1.6 km)	-1
Ambient Luminance	High	LZ3 and LZ4	1
	Moderate	LZ2	0
	Low	LZ1	-1
Guidance	Good	> 100 mcd/m ² lx	0
	Poor	< 100 mcd/m ² lx	0.5
Pedestrian/Bicycle Interaction	High	> 100 pedestrians per h	2
	Moderate	10–100 pedestrians per h	1
	Low	< 10 pedestrians per h	0
Parked Vehicles	Yes	Parked vehicles present	1
	No	Parked vehicles not present	0

Adapting to Traffic Volume

- Traffic demand model
- Average Daily Traffic (ADT) vs. Hourly Traffic
- Vehicles per lane vs. vehicles in direction of travel

Parameter	Options	Criteria	Weighting Value
Traffic Volume	High	> 1,500 vehicles hourly per lane	1
	Moderate	750–1,500 vehicles hourly per lane	0
	Low	< 750 vehicles hourly per lane	-1

Traffic Volume Data



DOE SSL Program Model Specification

 **ENERGY.GOV**
Office of Energy Efficiency & Renewable Energy

Search Energy.gov

SERVICES EFFICIENCY RENEWABLES TRANSPORTATION ABOUT US OFFICES >

[Home](#) » Model Specification for Networked Outdoor Lighting Control Systems

MODEL SPECIFICATION FOR NETWORKED OUTDOOR LIGHTING CONTROL SYSTEMS

- [Home](#)
- [About the Solid-State Lighting Program](#)
- [R&D Program](#)
- [Market-Based Programs](#)
- [SSL Basics](#)
- [Using LEDs](#)
- [Information Resources](#)
- [Financial Opportunities](#)

The DOE Municipal Solid-State Street Lighting Consortium's Model Specification for Networked Outdoor Lighting Control Systems is a tool designed to help cities, utilities, and other local agencies accelerate their adoption of systems that can further reduce the energy and maintenance costs of operating their streetlights. While the capabilities of monitoring and control systems on the market are enticing, many of these raise questions for users who are uncertain about how (or even if) they should be implemented, and how their true value can be assessed. As a result, user interests currently vary widely and are likely to do so for the foreseeable future, until adaptive lighting best practices and the ability to forecast energy and maintenance savings (along with the value of other features) becomes more universally proven.

A major update to the original Model Specification for Adaptive Control and Remote Monitoring of LED Roadway Luminaires has been released and this version, V2.0, has been renamed "Model Specification for Networked Outdoor Lighting Control Systems" to better reflect its evolving scope. The Model Specification remains a work-in-progress, a living document that reflects user experiences and the changing commercial market. Major updates in V2.0 include: the introduction of a Backhaul Communication Network section with associated requirements; separation of the Start-Up and Commissioning sections with updated or enhanced requirements for both; and further refinement focused on facilitating independent bids for Central Management System(s), Backhaul Communication Network(s), and Field Devices. The latter focuses on improving user ability to tender multi-vendor, multi-bid projects. V2.0 also includes more user notes, new and updated references to industry standards activities, and continued clarification of specifications recommended for all users vs. those deemed optional and likely to be only required by some users.

Download the [Model Specification for Networked Outdoor Lighting Control Systems, V2.0](#)

The MSSLC welcomes questions about the goals and development of this tool, and any suggestions for its further improvement. Municipalities or utilities who are particularly interested in future developments regarding the model specification are encouraged to inquire about joining the MSSLC task force that continues to engage and track the development and deployment of this energy-saving technology, and seeks ways to improve this resource. Please send comments and questions to MSSLC@pnnl.gov.

<http://energy.gov/eere/ssl/model-specification-networked-outdoor-lighting-control-systems>

Thank you for your attention.

QUESTIONS?