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Designers Lighting Forum

Understanding Solar Lighting

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March 8th

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Learning Objectives

At the end of this course, participants will be able to:

1. Analyze the components of a solar lighting system and understand what is involved in designing a system

2. Compare solar lighting systems and understand the various operating and control methods

3. Describe how solar lighting ties with the Dark Sky and Responsible Outdoor Lighting at Night movement

4. Identify potential projects where solar power lighting would be an appropriate solution

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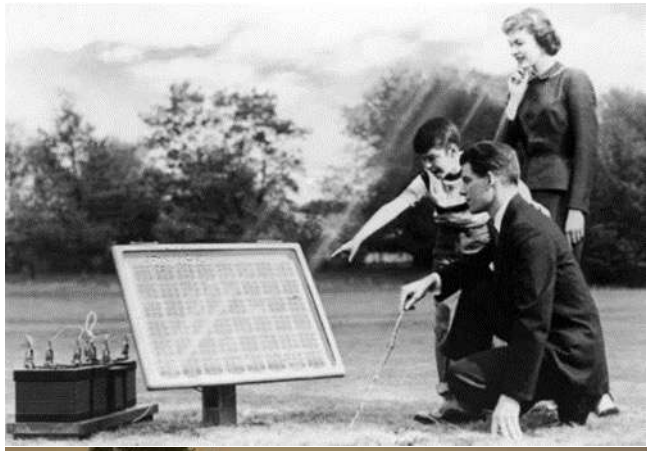
UNDERSTANDING SOLAR LIGHTING

How it began:

- French Electrical Engineer – Willoughby Smith in 1873 observed photoconductivity in practice in selenium (a semiconductor)
- American inventor Charles Fritts in 1883, credited for the first solid solar cell – around 1% efficiency – today over 20%
- DOE Sponsored Solar Decathlon – 2005 Virginia Polytechnic Institute and State University for Architecture and Lighting



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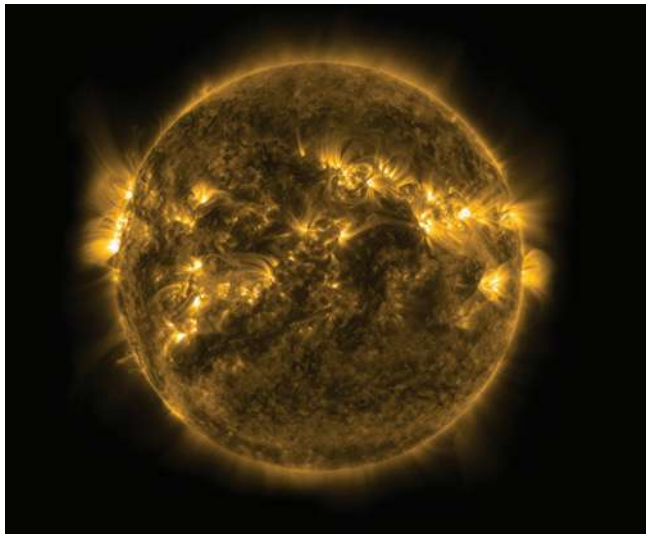
UNDERSTANDING SOLAR LIGHTING

Why Solar:

- Solar systems derive clean, pure energy from the sun
- Combat green house gases
- Green alternative to traditional power
- Renewable energy source
- Reduce dependance on fossil fuels
- Provide lighting to areas where grid power is not available
- Off electric grid – no trenching required



"U.N. Report officers bleak view on our climate – without political courage, the planet will pass dire emissions marker in 8 years.

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BENEFITS OF SOLAR LIGHTING

Go green

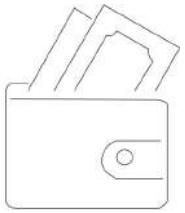
- Solar power is the number one renewable energy source. It is a great way to transition to going green. It takes absolutely nothing from grid power and is naturally produced.

Low maintenance

- LEDs are extremely long lasting. If properly installed, the system's batteries will only need some maintenance only every 5-7 years.

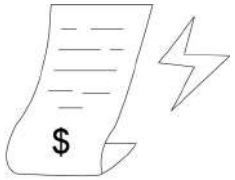
Cost effective installation

- Installation is considered low cost, as it is less expensive than trenching grid power. There is no underground running conduit to the light poles like you would see with traditional power.



Low energy bills

- Reduce energy bills to zero. Though a commercial system can have a higher upfront cost, the savings by utilizing solar power will pay back dividends on this investment.



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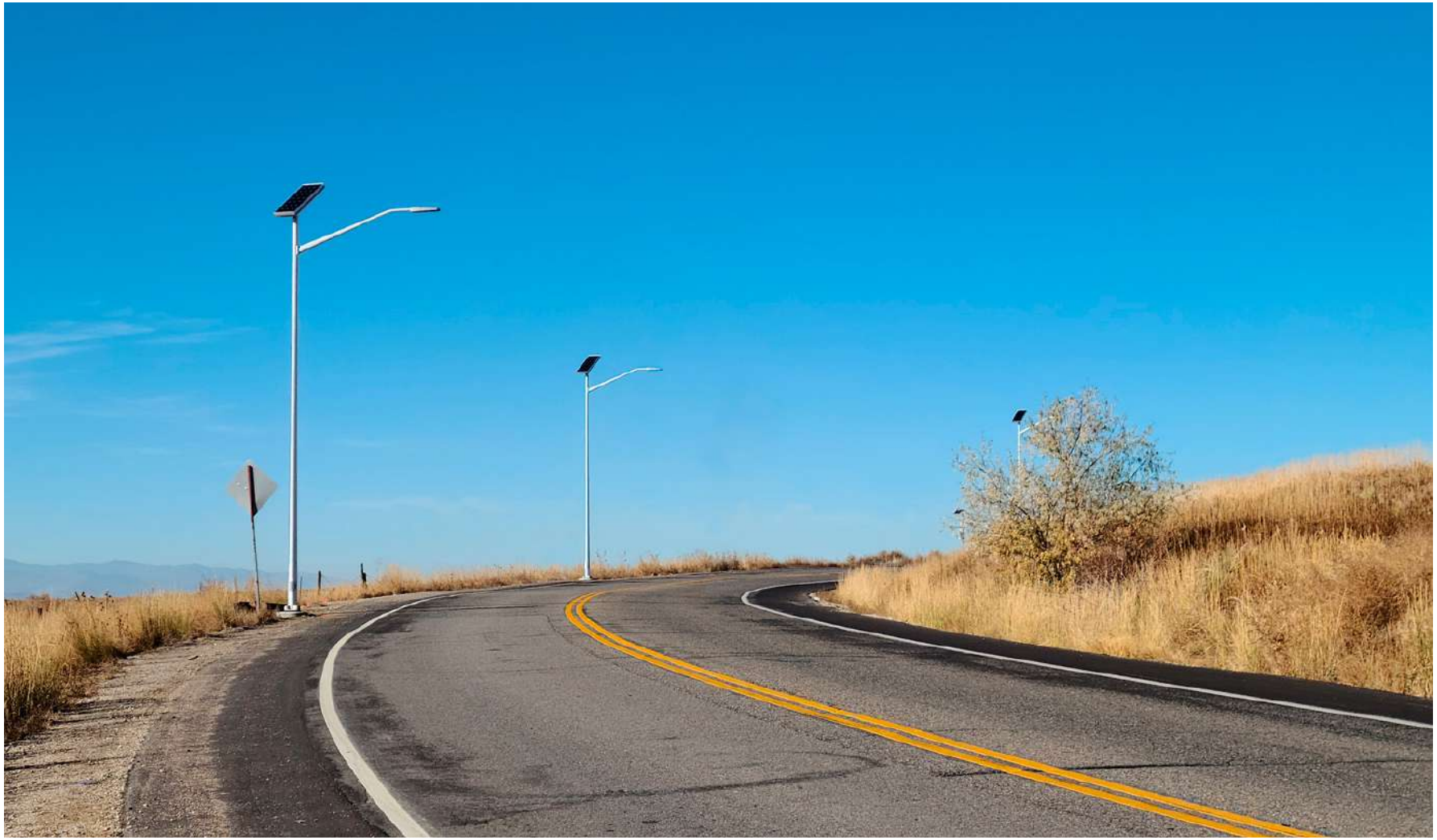

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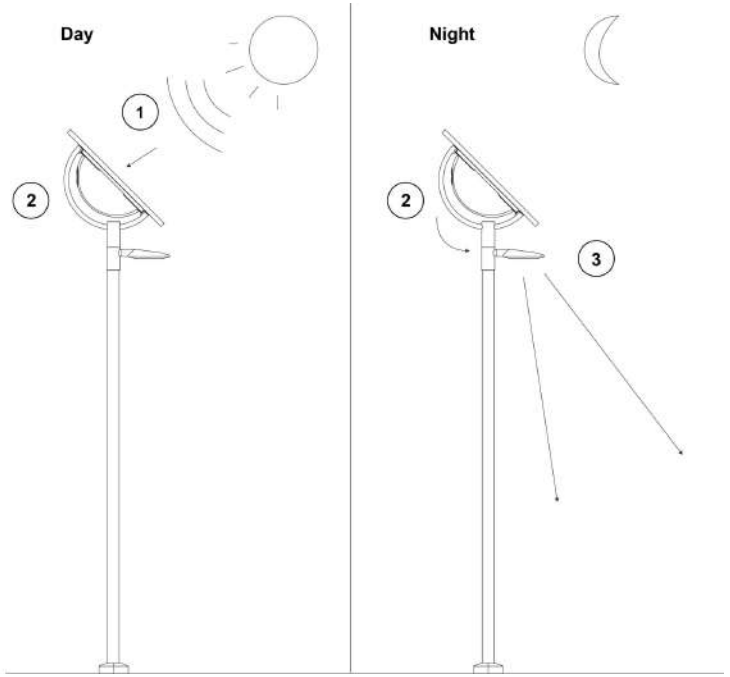
UNDERSTANDING SOLAR LIGHTING

How it Works:

1) During daylight hours, photovoltaic modules gather solar irradiation.

2) The solar irradiation is converted to electricity and stored in the battery.

3) At nighttime, the battery releases its energy to power the luminaire per the programmed lighting profile.



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COMPONENTS OF SOLAR LUMINAIRE

PHOTOVOLTAIC MODULES

Angled PV Panels

- Angled panels specific to project requirements


Vertical PV Tubes / Panels

- Vertically oriented tubes or panels (360deg)


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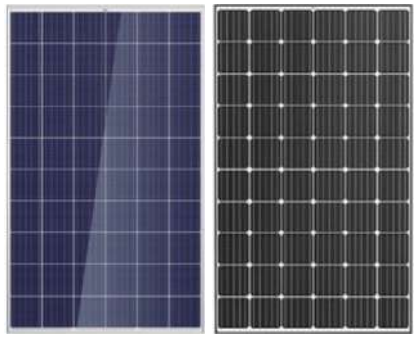
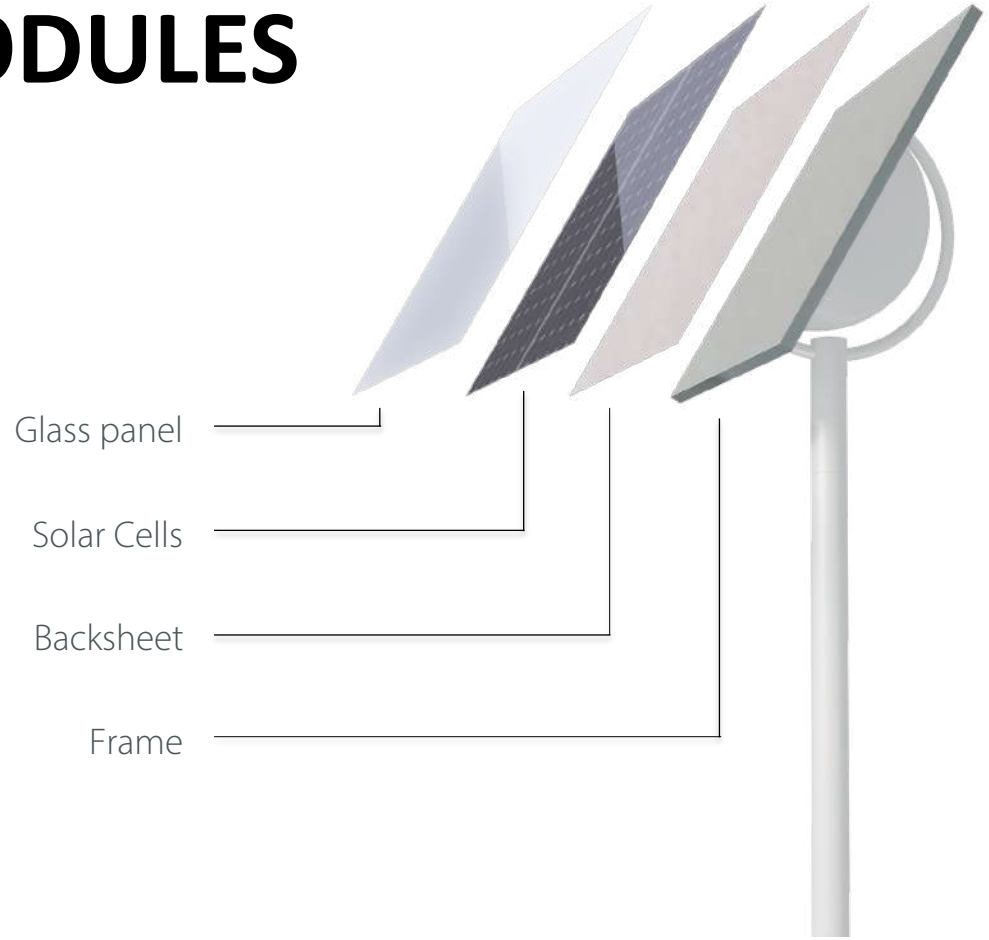
PHOTOVOLTAIC MODULES



Poly Mono

Panels

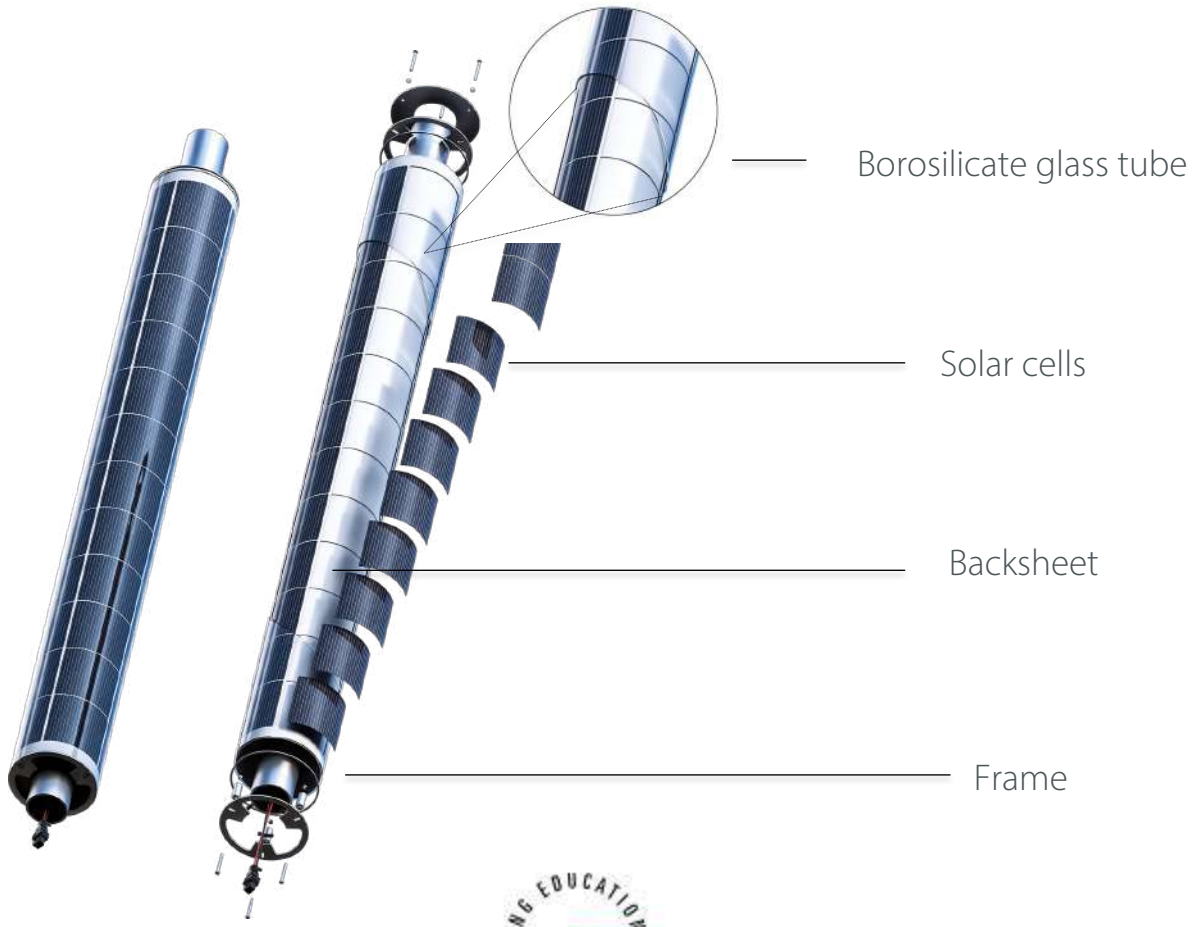
- Polycrystalline cells
  - 15% to 22% efficiency
- Monocrystalline cells
  - 22% to 27% efficiency



PHOTOVOLTAIC MODULES

PV Tubes / Panels

- Vertically oriented tubes or panels (360deg)
  - 20% to 27% efficiency



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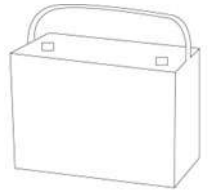
TYPES OF BATTERIES



Nickel Metal Hydride (NiMH)

- Fully dischargeable
- Safer with less active materials than NiCd
- Longer charging times
- Requires more maintenance

Absorbent Glass Mat (AGM)

- Low maintenance lead acid battery
- Work in extreme temperatures
- Least expensive
- Requires regular maintenance

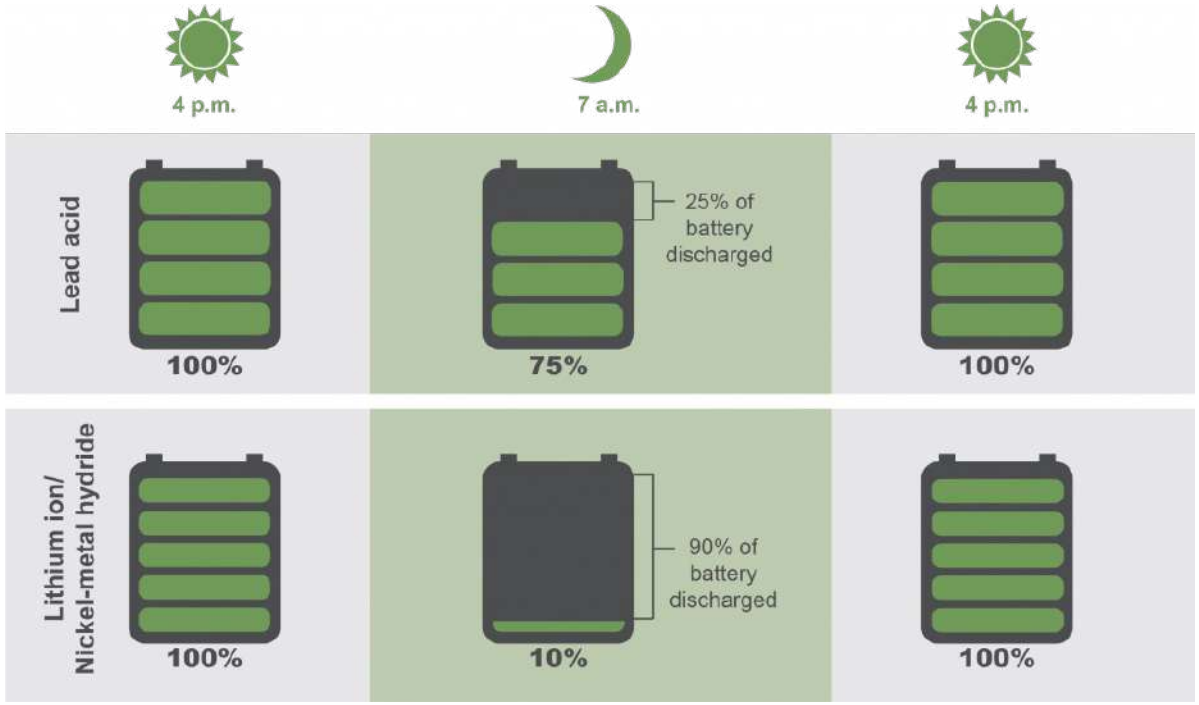
Lithium Iron Phosphate (LiFePO4)

- Most efficient battery type
- High discharge and recharge rates
- Long cycle life
- Compact and lightweight
- More expensive
- Smaller operating temperature range

Gel

- Lead acid battery
- More expensive than AGM
- Better DoD than AGM
- Requires regular maintenance

DEPTH OF DISCHARGE AND RECHARGE



BATTERY SIZING EXAMPLE

Battery Type (Depth of Discharge)	Minimum Battery Capacity Requirement (Load ÷ DOD)
Lead acid (25%)	560 ÷ 25% = 2240 Wh
Lithium ion (90%)	560 ÷ 90% = 623 Wh
Nickel-metal hydride (90%)	560 ÷ 90% = 623 Wh

Example:

40W luminaire x 14-hour night = 560Wh

Battery Type and Depth of Discharge	Battery Capacity Supplied by Manufacturer x max. DOD	Compare to Client's Load Requirements	Analysis of Battery Sizing
Manufacturer A (Lead acid: 25% DOD)	3400 Wh x 25% = 850 Wh	560 Wh load is less than the 850 Wh maximum discharge.	✓ This shows healthy battery sizing.
Manufacturer B (Lithium ion: 90% DOD)	1200 Wh x 90% = 1080 Wh	560 Wh load is less than the 1080 Wh maximum discharge.	✓ This shows healthy battery sizing.
Manufacturer C (Lithium ion: 90% DOD)	500 Wh x 90% = 450 Wh	560 Wh is greater than the 450 Wh maximum discharge.	✗ This shows unhealthy battery sizing. Light outage, unscheduled dimming, or premature battery failure is expected.

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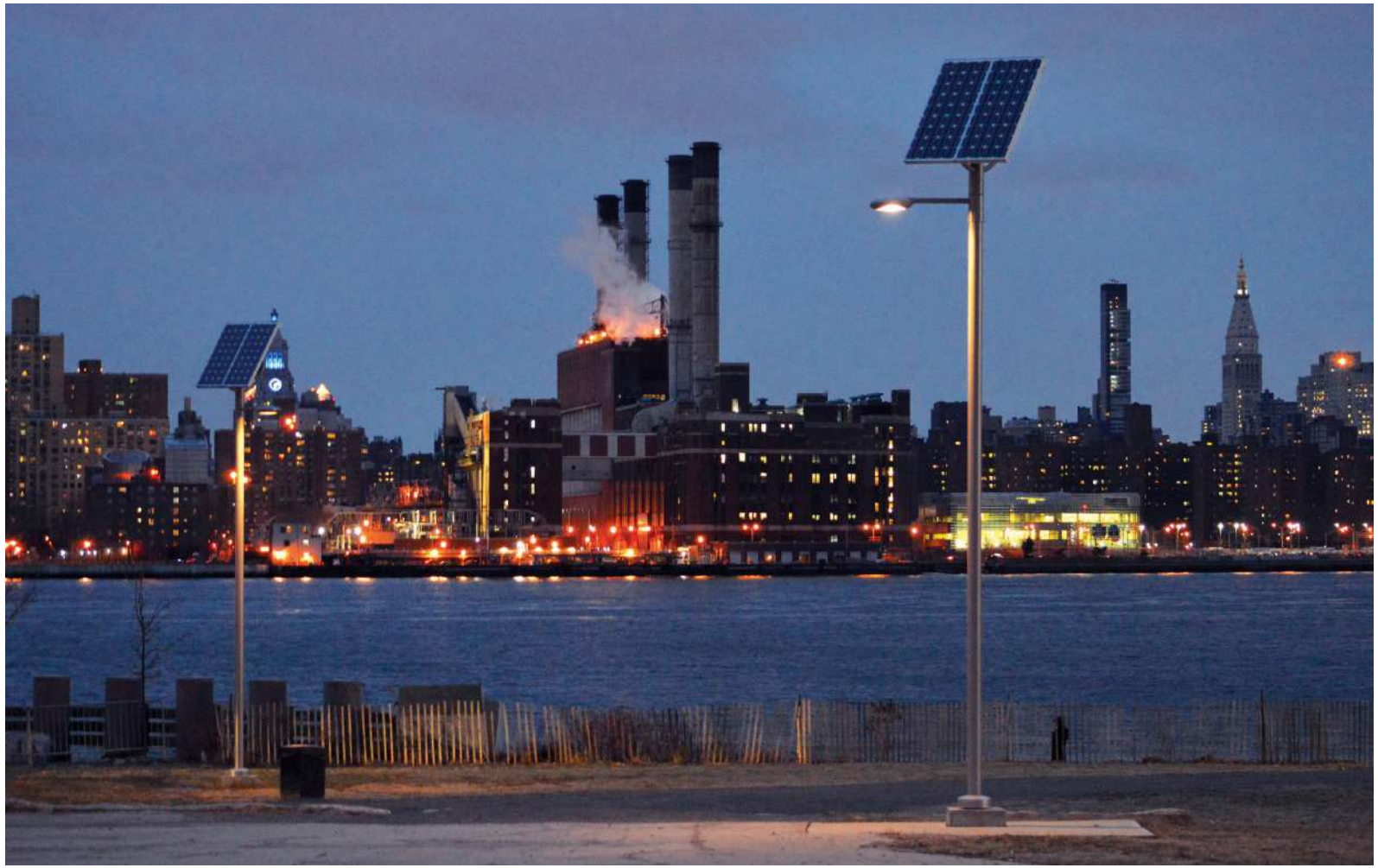

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SYSTEM MANAGEMENT

Controllers / EMS

- Monitors and regulates charging and discharging of batteries
- Programmable per run profile
- Power reserve for non-charged days

Remote Monitoring

- Avoid outages or reduce luminaire downtime with a system that tells you when a luminaire needs attention

Motion Sensors

- Use pole or integral luminaire motion sensors to detect occupancy and further save energy when light is not needed

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IS SOLAR RIGHT FOR YOUR PROJECT

Access to sunlight

- Minimal to no sun obstruction

Off grid requirements

- No access to tie to grid

Carbon footprint reduction

- Decrease pollution from chemicals and other contaminants

Lower electrical or installation costs

- Good ROI

Credits

- LEED, renewable rebates, etc.

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HOW TO SIZE A SOLAR SYSTEM

It's a balancing act!

- Project location
  - how much sunlight is available?
- What's the system load? (Array-to-load ratio - ALR)
  - How much light is required – illuminance & luminance calculations, luminaire/pole spacing, wattage requirements, etc.
- Desired operating profile
  - how will the luminaire be controlled?
  - Will it dim?
  - Will there be a motion sensor?

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HOW TO SIZE A SOLAR SYSTEM

Three key factors for a properly sized system

- Healthy array-to-load ratio (ALR)
- Sufficient battery capacity and backup power
- Efficient LED luminaire and operating profile

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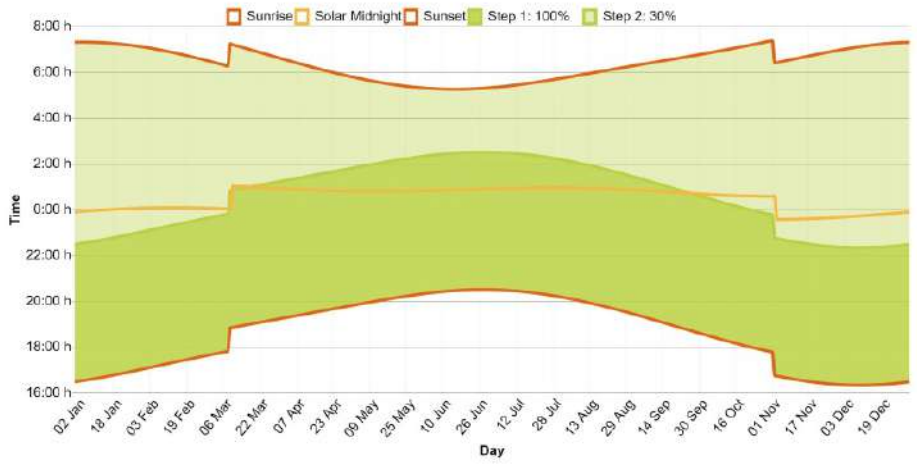
LIGHTING PROFILE

To allow for reliable illumination throughout the year, the following dimming profile is used:

	From		To		
Step	**Relative to**	**Offset (h)**	**Relative to**	**Offset (h)**	**Light Level (%)**
1	Sunset	0	Sunset	6	100
2	Sunset	6	Sunrise	0	30

The dimming profile for Chicago over the year performs as follows:



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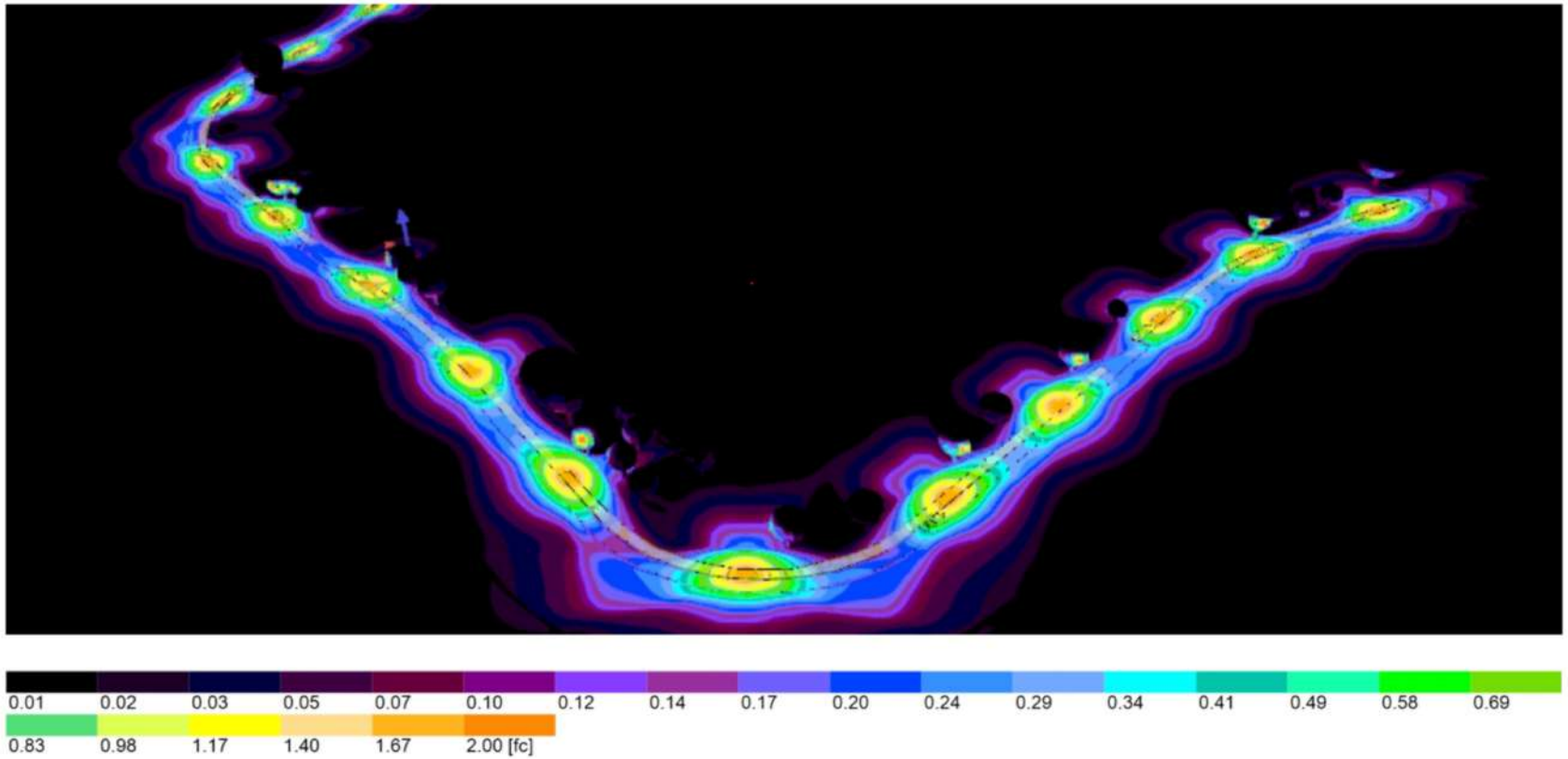
LUMINANCE / ILLUMINANCE CALCULATIONS



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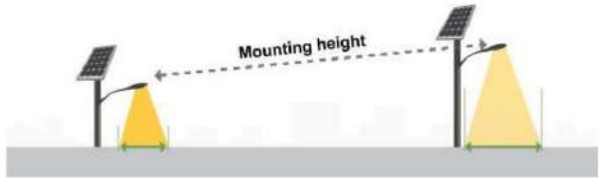
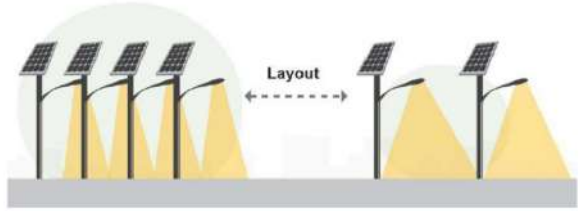
LUMINANCE / ILLUMINANCE CALCULATIONS

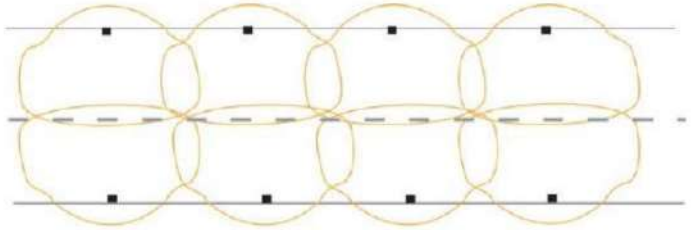
Mounting Height



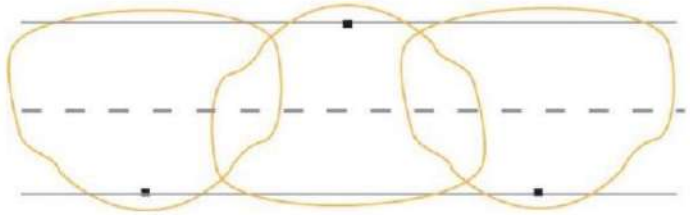
Layout / Spacing



Manufacturer X



Manufacturer Y



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SOLAR CALCULATOR

RECOMMENDED SYSTEM

Order Code DSCLS-R1-1-L25-30-B1-P1-3xxx-PM4-FINISH-MS

Description Solar-powered LED lighting system including series 25W white LED luminaire, 3000K, Type I Optics, Top of Pole Mounted Power Center with enclosed battery compartment, includes 110 watt solar array, 118Ahr battery capacity and MPT Controller with Motion Sensor-Polyester Powder Coated Color.

Pole Order Code TBD

Luminaire Detail	
Luminaire	Solar Light
Luminaire Qty	1
Wattage Each	25W
Color Temperature	3000K
Optics	Type I
System Lumens Total	1836lm
Finish	TBD

Power Package Detail	
Solar Panel	110W
Panel Qty	1
Battery	118Ahr
Battery Qty	1
Solar Panel Tilt	45deg
Options	MS - Motion Sensor

Lighting Profile	
Description	Preset 3: All night dim at 30%
Total Hours of Light	14.07

Calculated Energy-Balance for Site	
Energy In / Out (ALR)	4.28
Days of Battery Storage	8.27

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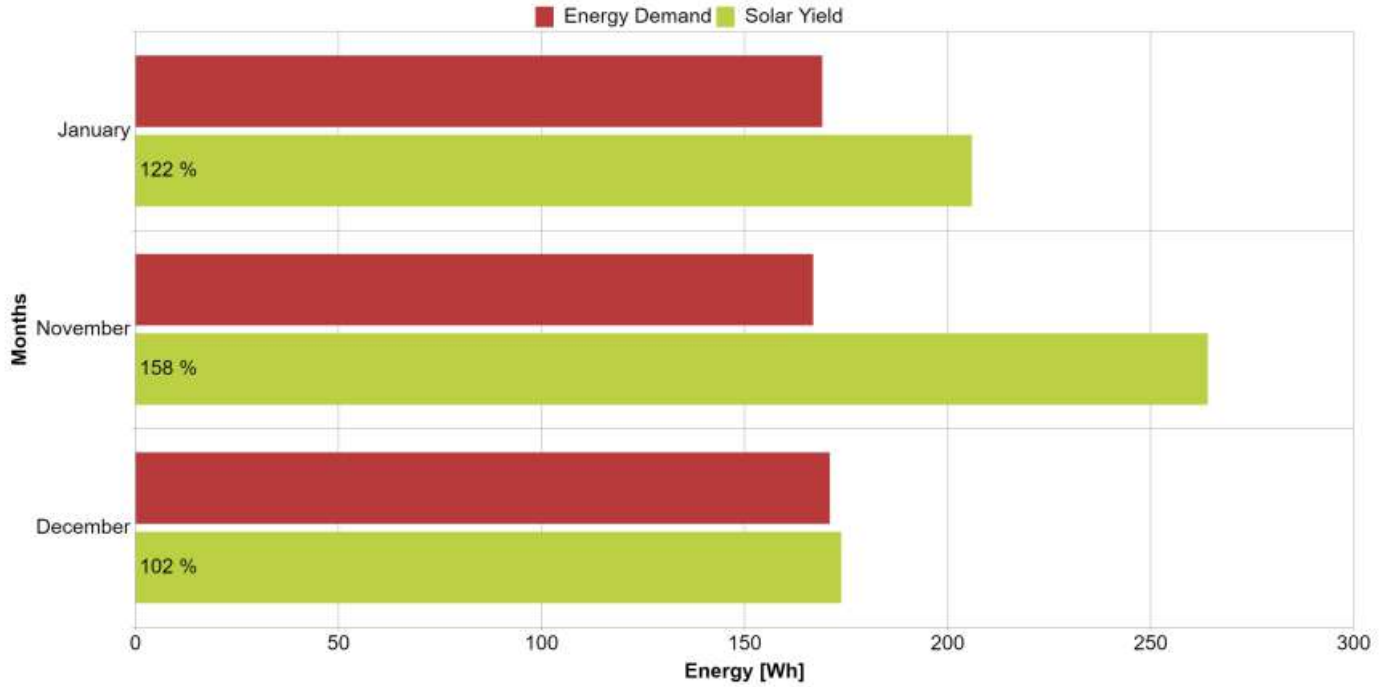
ENERGY DEMAND VS SOLAR YIELD



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EVALUATION AND DESIGN PROCESS FOR COMMUNITIES

Participants will be able to:

1) Assess existing streetlighting
2) Develop design objectives
3) Assess solar lighting practically
4) Evaluate currently available products
5) Estimate probable cost - ROI

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1. ASSESS EXISTING STREETLIGHTING AND LOCATION


F ST. BRIDGE

Historic Pedestrian

Historic Downtown


US-50 / E. RAINBOW BLVD

Transitional

Industrial

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2. DEVELOP DESIGN OBJECTIVES

Meet IES / IDA Responsible Nighttime Lighting

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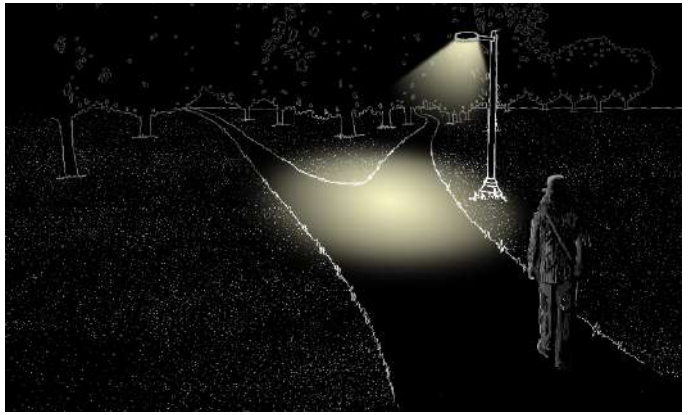
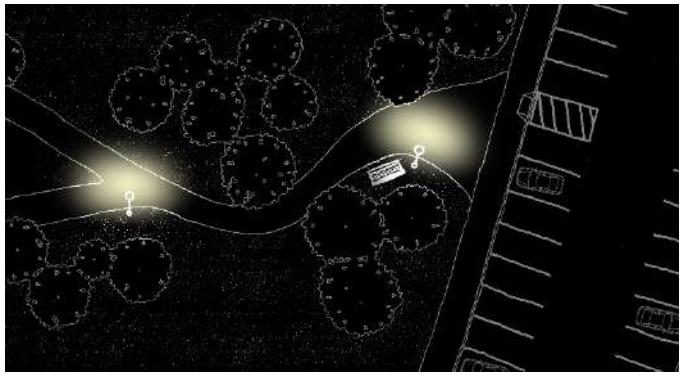
USEFUL

All Light should have a clear purpose





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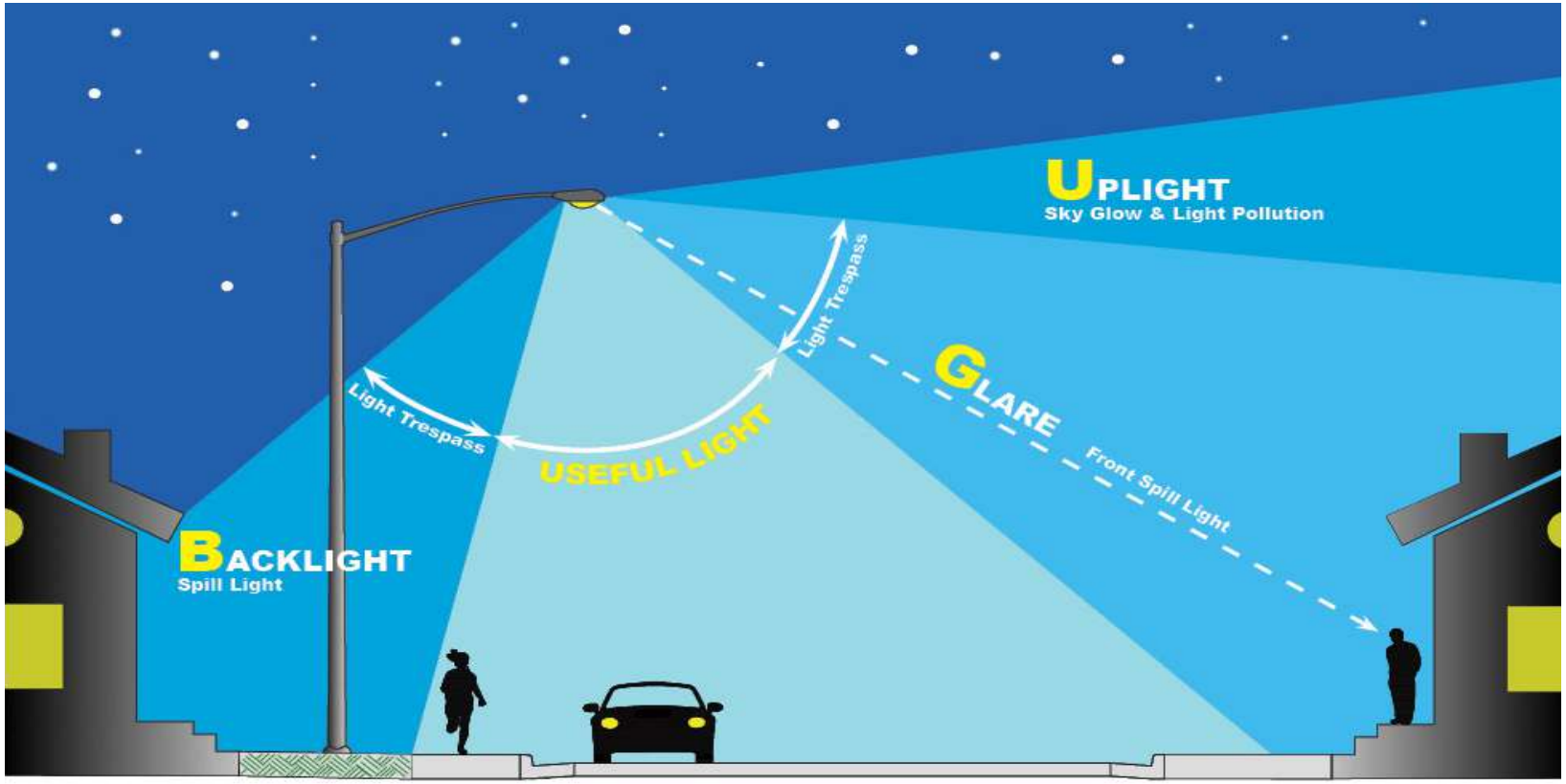
TARGETED

Light should be directed only where needed

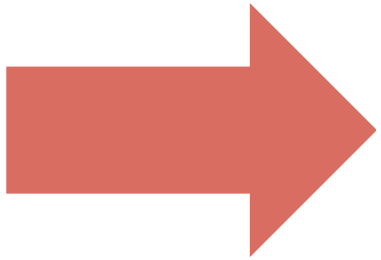
Light should be directed only where needed

Road Classification	Adjacent Land Use	High Pedestrian Conflict Area	Medium Pedestrian Conflict Area	Low Pedestrian Conflict Area
Arterial	Commercial	Continuous	Continuous	Non-Continuous
	Industrial	Continuous	Continuous	Non-Continuous
	Residential	Continuous	Non-Continuous	Non-Continuous
	Open Space	Continuous	Non-Continuous	Non-Continuous
Collector	Commercial	Continuous	Continuous	Non-Continuous
	Industrial	Continuous	Continuous	Non-Continuous
	Residential	Continuous	Non-Continuous	Non-Continuous
	Open Space	Non-Continuous	Non-Continuous	Not Warranted
Local	Commercial	Continuous	Non-Continuous	Non-Continuous
	Industrial	Continuous	Non-Continuous	Non-Continuous
	Residential	Non-Continuous	Non-Continuous	Non-Continuous
	Open Space	Non-Continuous	Non-Continuous	Not Warranted

Control Backlight, Uplight and Glare (BUG)



Use Dark Sky Compliant Luminaires



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Model with Landscape

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LOW LIGHT LEVELS

Light should be no brighter than necessary

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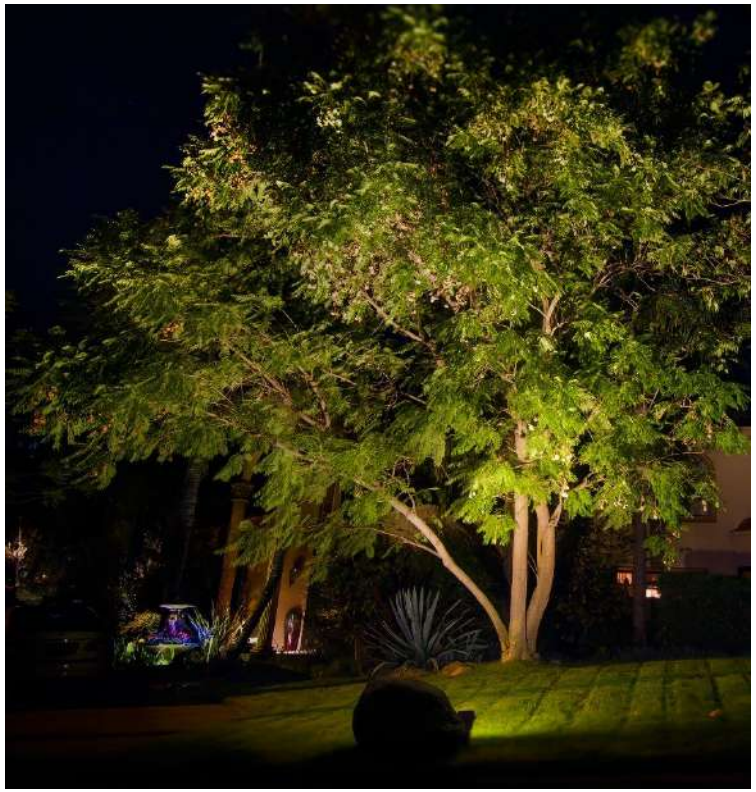
CONTROLLED

Light should be used only when it is useful

Controls … Controls and More Controls!!!!

1. All Lighting specified with **dimmable drivers**
2. Turn **off** non-essential lighting when no one is in the area
3. **Dim (10%)** all other lighting
4. Lighting control nodes



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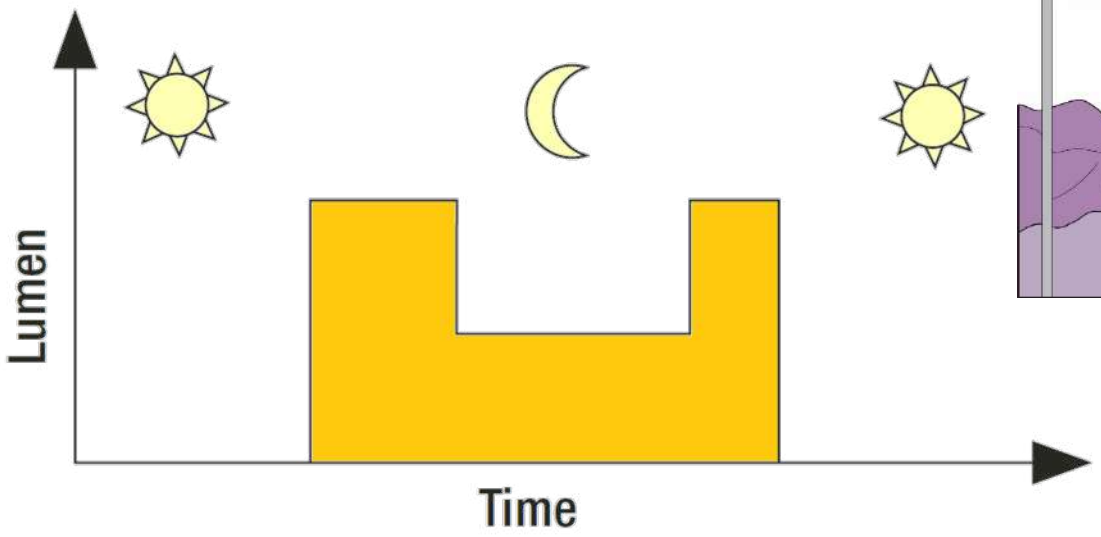
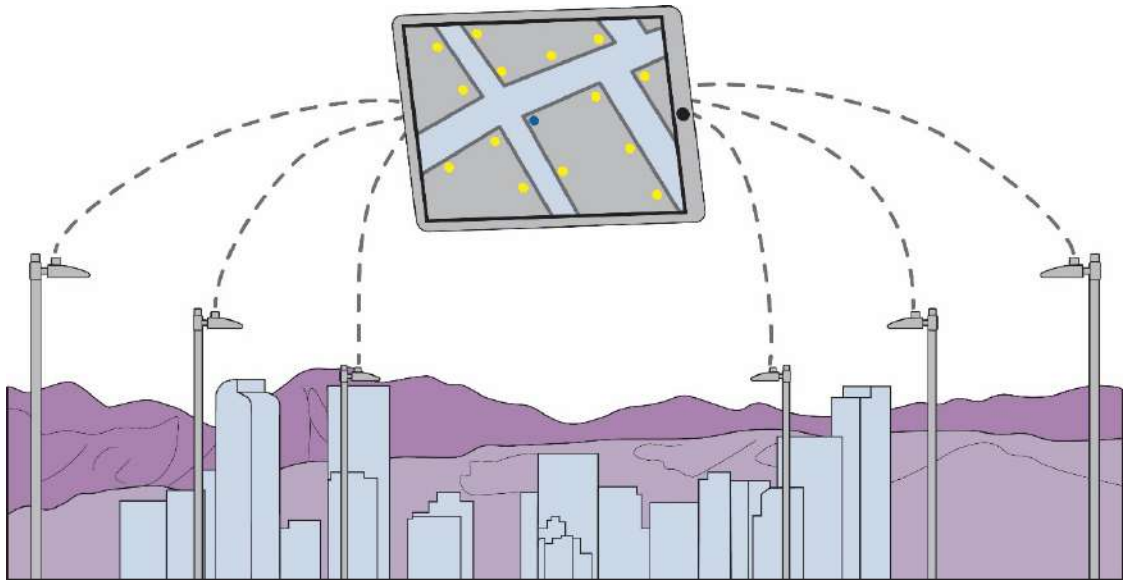
CONTROLLED

Controls

Bluetooth based monitoring and control:

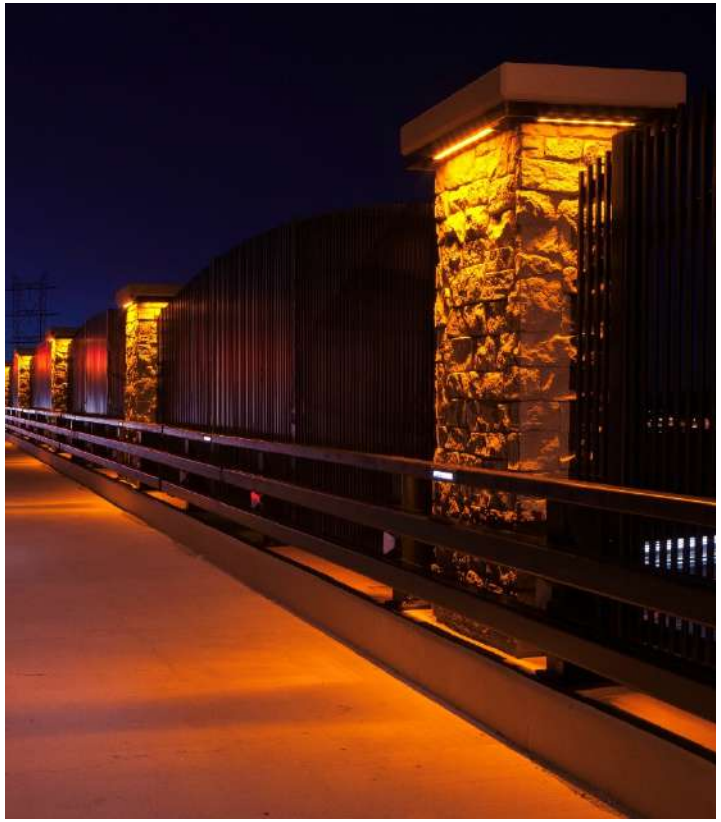
- Scheduling
- Dimming
- Set multiple profiles per day
- Monitor battery
- Access historical light and battery data.





COLOR

Use warmer color lights where possible



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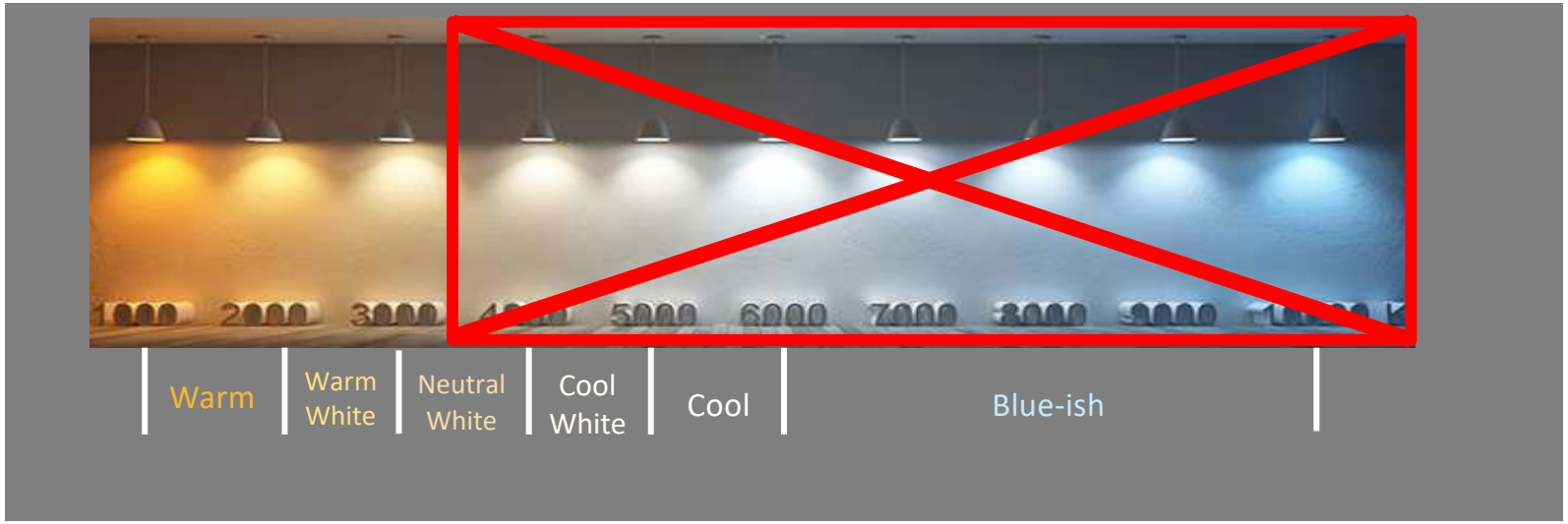
COLOR

Light Spectral Distribution ≤ 3000K



2. LIGHTING PROFILE

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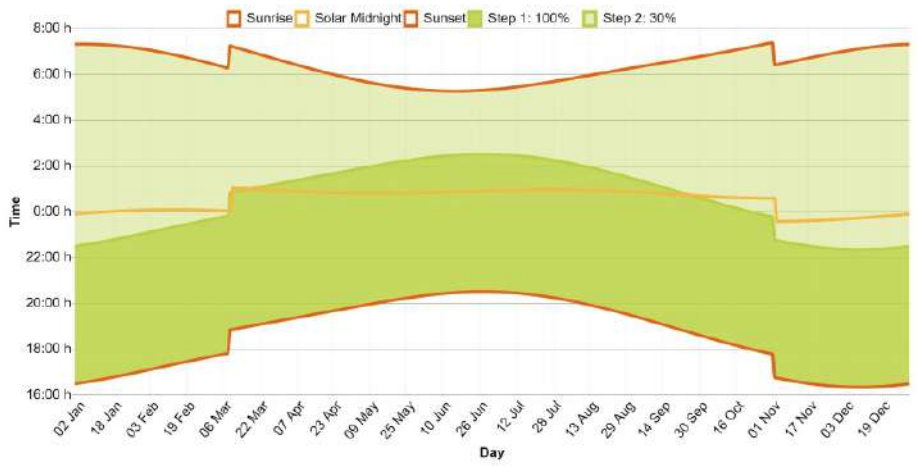
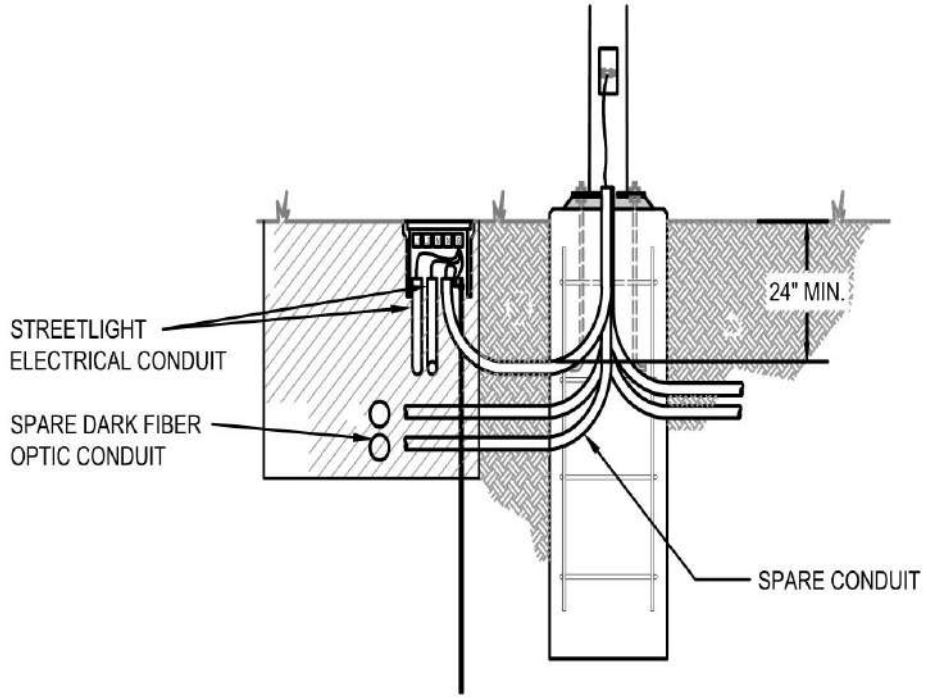


2. DEVELOP DESIGN OBJECTIVES

Solar Streetlighting vs. Electrical Fed Streetlighting:

1) Know what equipment is out there
2) Lighting control nodes
3) Fiber mapping
4) Underground infrastructure survey
5) Require GIS as-built maps



3. ASSESS SOLAR LIGHTING PRACTICALLY

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4. EVALUATE CURRENT AVAILABLE PRODUCTS

Compare and Contrast Based on Application:

- Solar angles (declination and azimuth)
- Wind exposure (EPA)
- Snow loads
- Luminaire type
- Battery enclosure style and position
- Aesthetic appeal

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Between Solstices © György Soponyai

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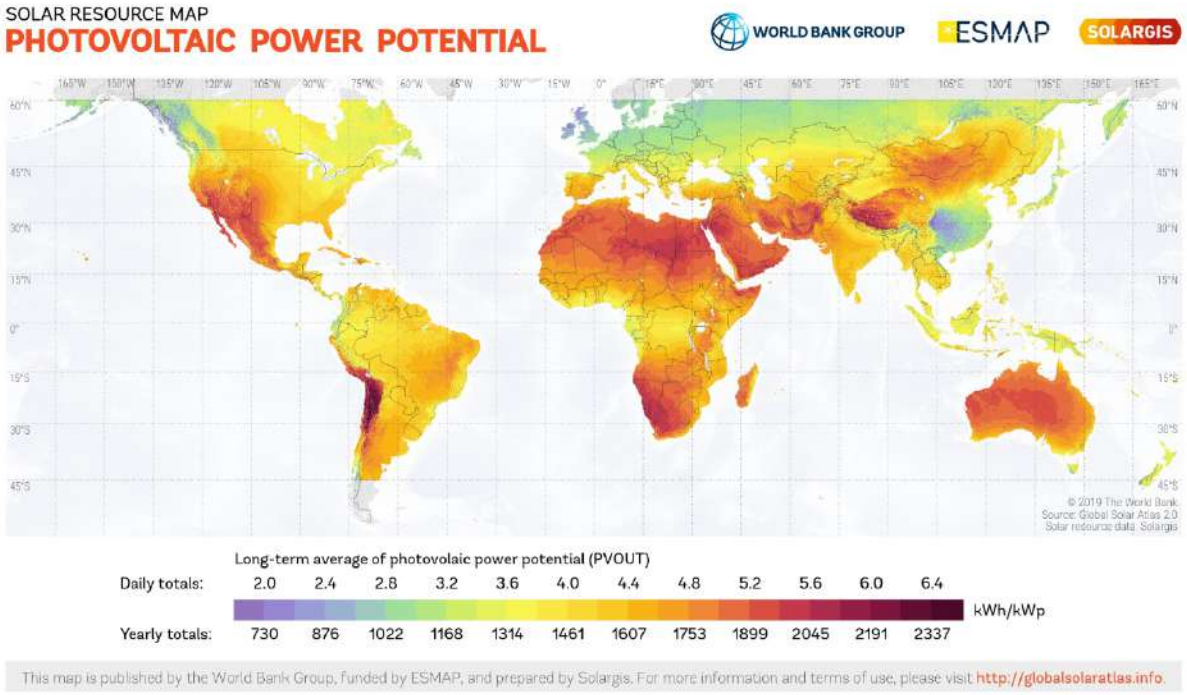
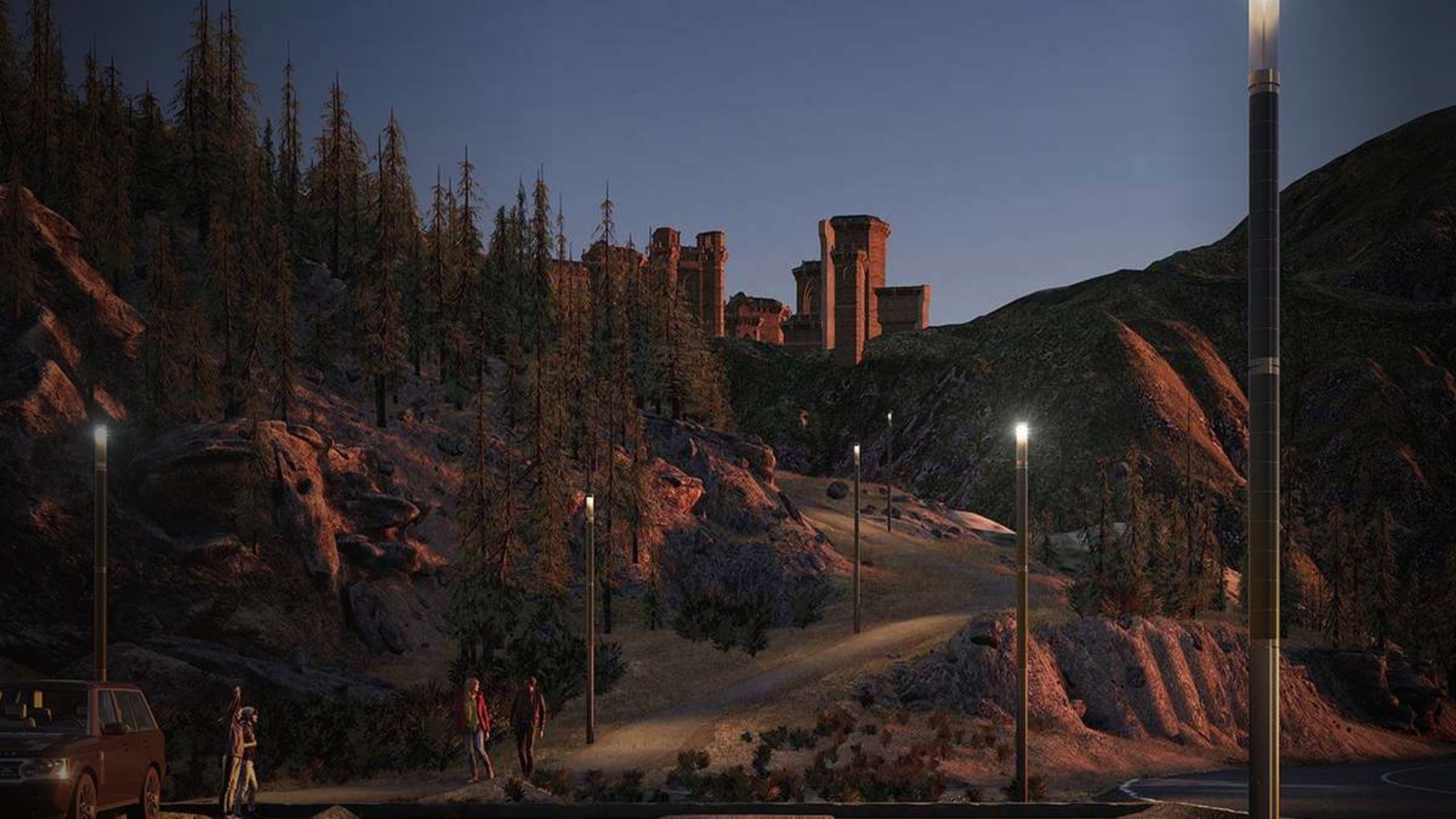
4. PHOTOVOLTAIC POWER POTENTIAL



Global Horizontal Irradiance and Average Night Length:

*Example above for Chicago, USA



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4. EVALUATE CURRENT AVAILABLE PRODUCTS

Checklist for Solar Streetlighting Systems:

- ✓ LED Luminaire (Efficacy, Distributions)
- ✓ Solar panel efficiency
- ✓ Charge control
- ✓ Maximum Power Point Tracking (MMT)
- ✓ Battery energy storage (Amp-hours or Watt hours)
- ✓ Battery chemistry
- ✓ Battery operating temperature range
- ✓ System autonomy
- ✓ Warranty
- ✓ EPA
- ✓ Enclosure for batteries – IP rating, aesthetics

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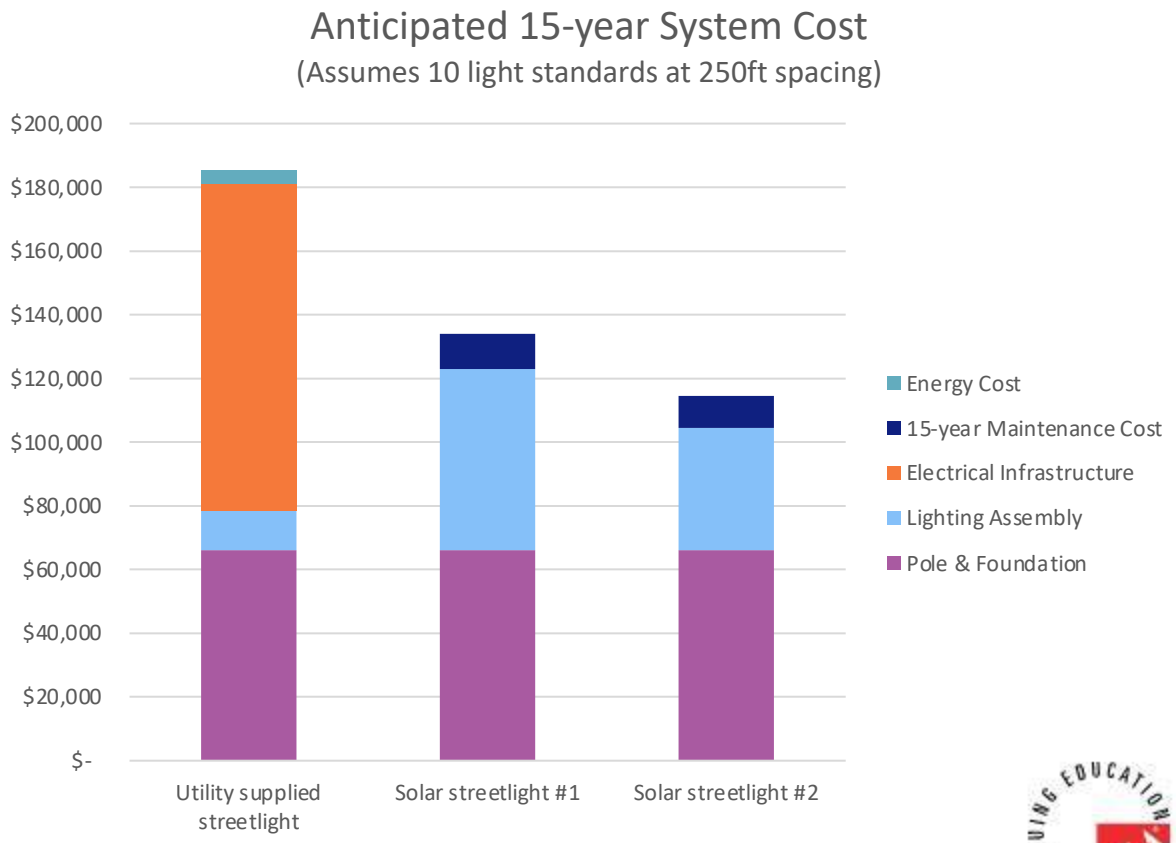
5. ESTIMATE PROBABLE COSTS - ROI

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THANK YOU!

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This concludes The American Institute of Architects Continuing Education Systems Course

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