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Authored by FLT | First Light Technologies

The 2026 Commercial & Municipal Solar Lighting Guide:

Evaluating Outdoor and Off-Grid Solar Lighting Systems for Long-Term Performance

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Executive Summary

As adoption of commercial outdoor solar lighting continues to grow, we still meet some skepticism. The concern is often rooted in experiences with early generation technologies and questions about long-term reliability. Despite advances in solar lighting technology, many sub-par systems are not designed for sustained performance in demanding outdoor environments.

For over two decades in the solar lighting industry, I have been focused on improving real-world performance through better energy management and system design. Efficiency, durability and energy management consistently prove to be the factors that influence long-term outcomes. For readers new to solar lighting, pages 2-8 build the foundational knowledge needed to evaluate systems and help interpret performance claims with confidence.

Brock Johnston - Director of Innovation

FLT | First Light Technologies

Reliability isn't about one single component, it's about how the entire solar lighting system is designed to work together. Battery chemistry, panel and charging architecture, controller intelligence, lighting controls and structural durability all interact. The system must work with available solar energy, deliver the required nightly performance and do it consistently for decades of exposure in harsh conditions.

Investment in solar lighting is accelerating across municipalities, public works departments and commercial developers through 2026 and beyond, and informed technology decisions have never mattered more. This guide intends to help specifiers and decision-makers evaluate solar lighting systems based on real-world performance with greater confidence. At FLT, we believe informed buyers make better long-term investments, and this guide is designed to help you make them.

Breaking Down the Battery in Solar Lighting Systems

Understanding Voltage, Current and Energy

Batteries store electrical energy—but in solar lighting systems, how power is generated, delivered and managed determines whether that energy is actually usable at night.

Solar lighting performance depends on the relationship between voltage, current, power and energy. Understanding how these basics allow specifiers to evaluate performance claims, compare systems accurately and avoid designs that look sufficient on paper but underperform in the field.

Power vs. Energy in Solar Lighting

- **Power (Watts, W)** - describes how quickly electrical energy is being used
- **Energy or (Watt-hours, Wh)** – describes the total amount of electricity stored in a battery and delivered over time
- In solar lighting, **runtime is determined by energy (Wh)**, not peak power **(W)**

Power ® is Current (I) × Voltage (V) (P = I × V)

High voltage and high current are required to deliver usable power.

Term	What it Means in Solar Lighting
Voltage (V)	Electrical "pressure"
Current (A) - Amperage	Flow of electricity
Power (W) - Wattage	Instantaneous output (V x A)
Energy (Wh)	Power delivered over time

The “Water Flow” Analogy for Power in Solar Lighting Systems

Batteries store electrical energy—but in solar lighting systems, how power is generated, delivered and managed determines whether that energy is actually usable at night. Solar lighting performance depends on the relationship between voltage, current, power and energy.

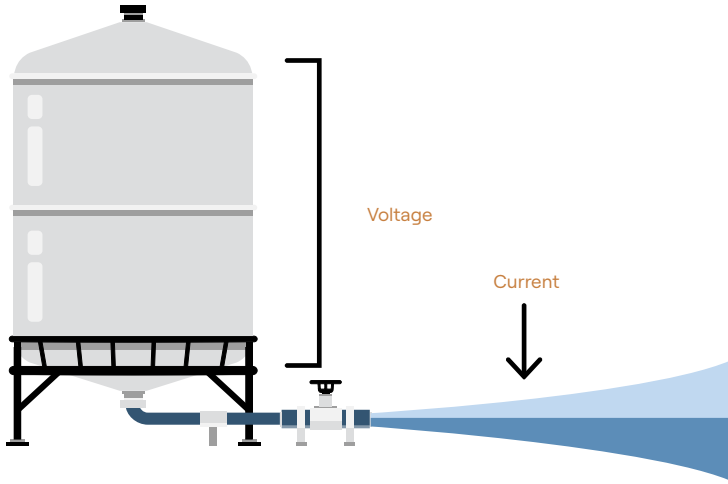
Think of electricity like water in a hose:

- **Voltage** is the water pressure (how hard it’s being pushed).
- **Current** is the amount of water flowing (how much water is moving).

When pressure and flow work together, you can do useful work—like cleaning a driveway.

For the best cleaning power, you want **both:**

- **High pressure** (high voltage) and
- **Lots of flow** (high current)



Power comes from both voltage and current working together

A strong solar lighting system needs the right balance of pressure and flow

Knowing how power works leads to smarter solar lighting choices

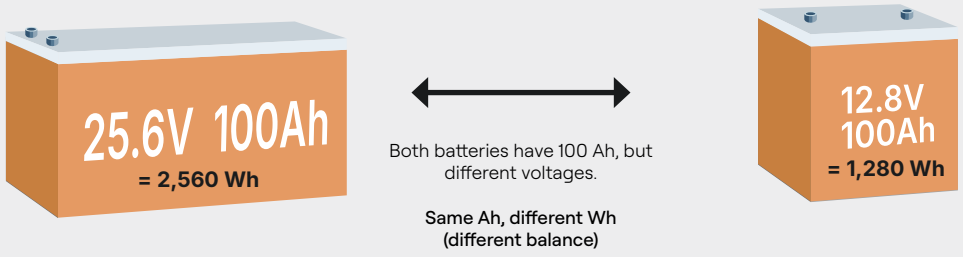
The Battery | Your Solar Bank Account

Think of the battery as your bank account, and nightly runtime as your spending. **Watt-hours (Wh)** represent the battery's bank account balance. A 50-watt light running for 10 hours uses 500 Wh per night. Since solar charging varies day to day, extra battery capacity helps protect performance during low-sun conditions.

Battery capacity in solar lighting systems is often listed in **amp-hours (Ah)**, but Ah does not account for voltage. Because solar lighting systems operate at different voltages, watt-hours (Wh) are the most reliable way to compare battery capacity.

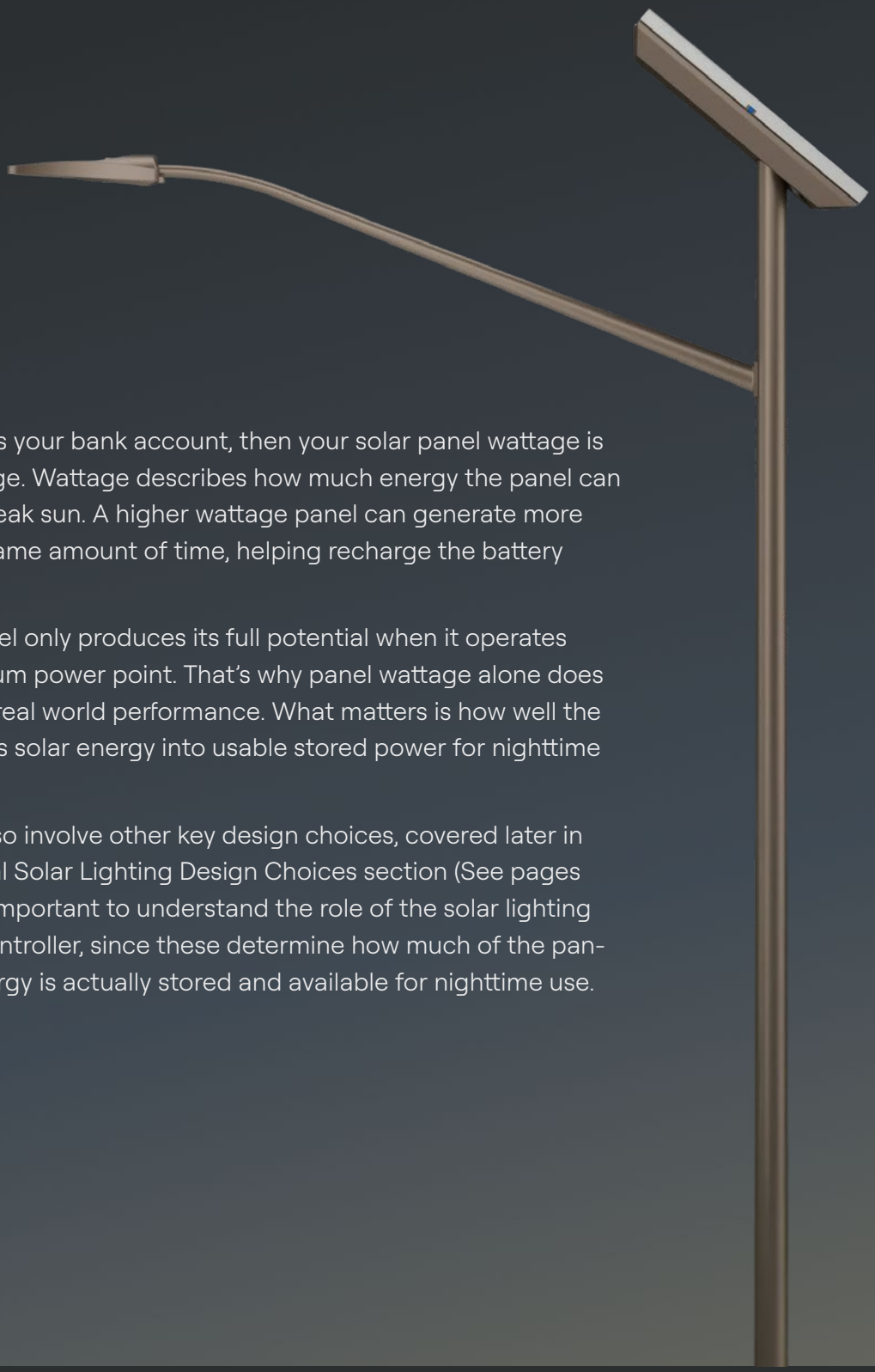
Amp-hours can be misleading unless the voltage is the same.

Watt-hours account for both voltage and current, showing your true battery balance.



These fundamentals provide the context needed to evaluate solar lighting systems, and interpret performance claims throughout this guide.

Solar Panel Wattage | Your Solar Hourly Wage



If your battery is your bank account, then your solar panel wattage is your hourly wage. Wattage describes how much energy the panel can "earn" during peak sun. A higher wattage panel can generate more energy in the same amount of time, helping recharge the battery more fully.

However, a panel only produces its full potential when it operates near its maximum power point. That's why panel wattage alone does not guarantee real world performance. What matters is how well the system converts solar energy into usable stored power for nighttime operation.

Solar panels also involve other key design choices, covered later in the Commercial Solar Lighting Design Choices section (See pages 10-11). First, it's important to understand the role of the solar lighting charger and controller, since these determine how much of the panel's earned energy is actually stored and available for nighttime use.

Charger vs. Controller | Cell Phone Analogy

A simple way to understand the difference is to compare it to a cell phone. While the underlying electronics are more complex, and these functions are sometimes integrated, the comparison helps illustrate the roles at a high level.

- Like a phone charger, the **solar charger's** job is to **deliver power safely and efficiently to the battery.**
- The **controller** would be like the phone itself—the brains of the operation. Deciding how energy is captured, stored and delivered each night, optimizes performance over time.

In a Solar Lighting System:

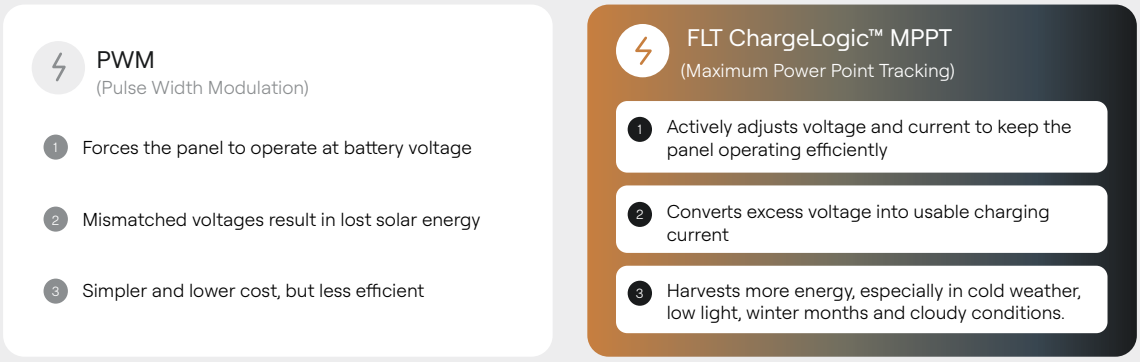
- The **charger** manages how energy flows from the **solar panel into the battery**, ensuring the battery charges properly and protects it from overcharging.

Solar Lighting Charger Options

One of the major technical differences between chargers is **PWM versus MPPT**. Different chargers determine how efficiently solar energy is converted into usable stored power.

Basic Phone Charger vs. Smart Phone Charger

- **PWM controllers operate like basic chargers**—simple and lower cost but less efficient
- **MPPT controllers operate like smart chargers**—actively optimizing energy transfer to capture more usable power.



MPPT is the most efficient charging option in the solar lighting industry. FLT ChargeLogic™ MPPT takes it further with factory calibrated and integrated specifically for FLT batteries, panels and controllers for optimized real-world performance.

FLT Adaptive Intelligence™ Lighting Controller

One intelligent platform powering the future of FLT solar lighting.

FLT Adaptive Intelligence™ Lighting Controller modernizes the technology at the core of commercial lighting systems, improving energy management, simplifying installation and enhancing long-term performance.

The brain of our solar lighting system, our controller optimizes how much energy is captured, stored and delivered each night, directly impacting performance efficiency and long-term reliability.

Key Features:

- **Auto-On functionality** - lights activate right out of the box for easy installation
- **Astronomical Lighting Control** - location-based sunset and sunrise control for synchronized fixture operation (compared to Light Sensing on Pg. 9)
- **Improved performance** in shaded environments
- **Advanced energy management** algorithms for optimized light output
- **Built in temperature monitoring** to optimize charging and extend battery life
- **Automotive-grade enclosure** for durability and easy serviceability
- **Future-ready design** to support upcoming enhancements

FLT Adaptive Intelligence™ Lighting Controller delivers consistent, high-performance illumination night after night. Its future-ready design means existing features can receive new controller capabilities as FLT technology evolves—protecting your investment for years to come.

The Right Combination: Battery, Charger & Controller

Not all solar lights are built the same. The battery chemistry, the charger and controller each independently affect how much energy is captured, stored and reliably delivered each night. Specifying the right combination is the single most impactful decision in commercial solar lighting.

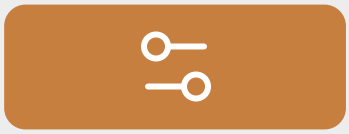
Many solar lights use MPPT chargers and $LiFePO_4$ batteries—but the quality, calibration and integration of each component determines real-world performance. Not all systems are engineered to work together.

FLT All-Weather™ Lithium Iron Phosphate ($LiFePO_4$)

More usable energy, longer cycle life and reliable performance in extreme temperatures compared to NiMH or Lead Acid alternatives.

FLT ChargeLogic™ MPPT

Actively optimizes voltage and current to maximize energy harvest. Especially in cold weather, shade and low-light conditions.



FLT Adaptive Intelligence™ Lighting Controller

Manages energy delivery intelligently each night—with astronomical lighting control, temperature monitoring and auto-on functionality.

> When evaluating any commercial solar light, ask for the battery chemistry, the charger type and controller capabilities—not just panel wattage or lumen output. Those three components determine real-world performance.
>
> FLT designs each component to work as an integrated system—from panel to pole—ensuring consistent, reliable illumination night after night.

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Commercial Solar Lighting Design Choices that Impact Performance

Light Control: Astronomical Lighting vs. Light Sensing

In outdoor solar lighting, how a fixture determines when to turn on and off directly affects reliability, consistency and how well it integrates with multi-fixture installations.

For municipalities and infrastructure projects requiring synchronized, predictable operation, the choice between Light Sensing and Astronomical Lighting is an important one.

	Astronomical Lighting	Light Sensing
Best Suited For:	Coordinated, multi-fixture solar lighting installations, where predictable operation and reduced false triggering are required.	Cost-sensitive, standalone solar lighting installations where fixtures operate independently and simplicity is a priority.
Key Strengths:	Predictable on/off timing based on time, date and location; ensuring consistent operation across multiple solar lighting fixtures.	Simple solar lighting technology with minimal configuration, making it easy to deploy and maintain in basic installations.
Key Considerations:	More sophisticated system requiring smart controllers	May not turn on if nearby lights are present (especially for bollard applications) Fixtures can turn on and off at different times Can activate during heavy cloud cover

FLT offers both Light Sensing and Astronomical Lighting control. The majority of FLT fixtures feature Astronomical Lighting, with Light Sensing available on select products such as the PLB and WLB.

Commercial Solar Lighting Design Choices that Impact Performance

Product Configuration for Outdoor Installations

In outdoor solar lighting applications, product configuration directly affects energy harvesting, installation and design flexibility across different climates and site conditions. FLT products use either of two configurations, chosen based on the application: self-contained products, with all components integrated directly into the luminaire, and distributed products, with a solar engine separate from the luminaire.

Self-Contained

Distributed

Fewer components and connection points, for a faster, simpler install	Panel can be oriented independently of the luminaire, allowing optimal tilt toward the sun
Clean, integrated aesthetic — no separate luminaire or extra hardware	Mounting flexibility supports sites where placement options matter most, such as large-scale streetlights
Compact footprint, well suited to pathway, park and streetscape fixtures where appearance matters most	Used on FLT's highest-output products, where maximizing energy harvest is the priority
The configuration behind the majority of the FLT line, reflecting its fit for most site conditions	

Both configurations are engineered as part of FLT's integrated solar lighting system. Lighting requirements and location determines which product configuration applies: self-contained for the core product line, distributed where output and placement flexibility take priority.

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Commercial Solar Lighting Design Choices that Impact Performance

Solar Cell Technology for Solar Lighting: Conventional Panel vs. FLT Active Cell™ Solar Panels

A solar panel is made up of many individual solar cells, each of which converts sunlight into electricity. In commercial solar lighting systems, how electricity is collected from each cell—either from the front or the back—directly affects efficiency, shade tolerance and real-world performance in outdoor environments.

	Conventional Panel	FLT Active Cell™ Solar Panels
How it Works:	Electrical contacts are located on the sun-facing surface of the cell	Electrical contacts are moved to the rear of the cell
Key Strengths:	Commonly used, industry-standard cell design	Full sun-facing surface exposed for light capture
Key Considerations:	Front-side metal lines partially block light and are more sensitive to shading or debris	Higher real-world efficiency → same power with less panel area → smaller product
Visual Appearance:	Visible grid lines on the cell surface	Clean, uniform cell appearance

These cell-level design differences influence solar energy capture and reliability, especially in shaded, urban or debris-prone installations. FLT Active Cell™ Solar Panels eliminate front-surface obstructions entirely, delivering more consistent performance where standard panels fall short.

LED Color Temperature Choices for Commercial Solar Lighting

LED color temperature impacts how solar lighting looks and performs in real-world environments. Measured in kelvin (K), it influences perceived brightness, visual comfort and environmental impact across applications from pathways to roadways and security lighting.

The table below compares common LED color temperature options used in commercial solar lighting and when each is most appropriate.

Rating	Color Temperature / Type	Light Appearance	Common Uses	Key Benefits	Considerations
Bright	2700K-3000K (Warm White)	Soft, yellowish warm	Parks, pathways, urban pedestrian zones, hospitality	Welcoming low glare, wildlife friendly	Needed for Dark Sky requirements
Brighter	4000K (Neutral White)	Clean, balanced white	Walkways, campuses, streets, parking lots	Balanced comfort + visibility, versatile	Less warm than 3000K
Brightest	5000K – 6500K (Cool White/Daylight)	Bright, crisp, bluish-white	Roadways, parking lots, security, industrial	Brightest, high contrast, solar-efficient	Harsher feel, degrades night vision
Bright	Lumileds NightScape Technology™ (≈3000K, spectrally optimized)	Warm white with reduced blue content	Urban streets, park roads, dark sky zones.	Reduced sky glow, comfortable visibility	Slightly lower efficacy, premium LED option
Low Brightness	1800K–2200K (Amber)	Very warm, amber/orange	Coastal parks, wildlife sensitive areas	Lowest ecological impact, ultra-low glare	Poor color rendering, limited brightness, niche use
Bright	RGB / Tunable White	Adjustable color or CCT	Public spaces, amenity lighting	Adjustable color, dynamic control	Higher cost, added complexity

FLT offers 2700K, 3000K, 4000K, Amber and 1850K Lumileds NightScape Technology™. This range reflects a deliberate focus on lighting that works with the human eye, not against it. Our options give specifiers the right selection for virtually any municipal or commercial application.

Environmental Considerations for Outdoor Solar Lighting

Environmental performance matters in outdoor solar lighting for public spaces and municipalities. Beyond energy efficiency, well-designed solar lighting reduces glare, light pollution, light trespass and sky glow—while improving nighttime visibility.

Understanding BUG Ratings (Backlight, Uplight and Glare)

BUG ratings describe how a luminaire controls Backlight, Uplight and Glare, influencing light pollution and visual comfort.

- Uplight is light directed into the night sky. Lower uplight supports dark sky goals.
- Backlight is light spilling behind the pole. In most roadway and pathway lighting applications, backlight causes light trespass onto nearby properties and is undesirable.
- Glare occurs when light is directed into your field of vision. Some glare is unavoidable in wide roads and paths, but reducing glare often impacts uniformity. Managing glare is a design trade-off when selecting light distribution.

BUG ratings are measured on a scale of 0-5—all of FLT's products are listed with certified BUG ratings to help you select the right fixture for your environment.

Lighting Profiles vs. Constant Output

Both options keep a site light all night, Lighting Profiles allow you to tailor the light output to the site or project's needs.

A lighting profile is a programmed schedule that adjusts brightness over the course of the night, while constant output maintains the same light level from dusk to dawn.

When aligned with how an area is used, lighting profiles are almost always the better choice. They reduce light pollution and lower power consumption, allowing for smaller, more cost-effective solar lighting systems.

However, lighting profiles must match actual usage. If output is reduced while a path or roadway is still heavily used, visibility and safety can be compromised.

DarkSky Approved vs. Dark Sky Compliant

These terms are often confused. While both aim to reduce environmental impact, they are not equivalent.

- DarkSky Approved solar luminaires are approved by DarkSky International based on manufacturer testing. They meet strict limits for uplight, color temperature and blue light and are often required for municipalities, parks and sensitive environments. FLT's lighting is designed to Dark Sky principles across the full product line, with the majority of FLT fixtures officially DarkSky Approved (excluding 4000K color temperature options). WLB is not DarkSky Approved, as certification is not a requirement for its wayfinding application.
- Dark Sky Compliant products follow dark sky principles but are not officially certified. Approval depends on local codes or project requirements.

Why Light Trespass Matters

Light trespass occurs when illumination spills beyond the intended area, affecting homes, wildlife and neighboring properties. FLT works with customers to optimize product selection and lighting layout design on each project to minimize light trespass and support responsible public illumination.

Conclusion

Truly reliable commercial solar lighting is the result of deliberate, system-level engineering. Long-term performance depends on how effectively energy is harvested, stored and delivered under real world conditions, rather than optimizing any single component. Battery chemistry, panel and charging architecture, controller intelligence, lighting controls and structural durability must all work together, night after night, across decades of exposure.

At FLT, our fixtures are built around the components and design principles that define leading-edge solar lighting:

- **FLT All-Weather™ $LiFePO_4$** - high efficiency battery chemistry with long cycle life, even in extreme temperature conditions.
- **FLT ChargeLogic™ MPPT** - maximum energy harvest from every panel, in all shade, cold weather and low-light conditions.
- **FLT Adaptive Intelligence™ Lighting Controller** - adaptive controls and astronomical lighting profiles for consistent dusk-to-dawn operation
- **FLT Active Cell™ Solar Panels** - full-surface energy capture for higher real-world efficiency
- **Durable, weather-tested structure** engineered for decades of outdoor exposure

At FLT, our commitment doesn't end at installation. We partner with municipalities, public work departments and commercial developers to ensure our systems perform in the real environments they were designed for, because we care as much about the outcome as the specification.

As communities expand sustainability and infrastructure investments through 2026 and beyond, choosing solar lighting partner with engineering depth, field experience and genuine long-term outcomes isn't just a smart investment, but a truly responsible one.