



U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

2011

Solar at Night: Technology Behind Solar LED

Speaker: Roger Lo

Sr. Design Engineer
Meteor Lighting



Course Outline

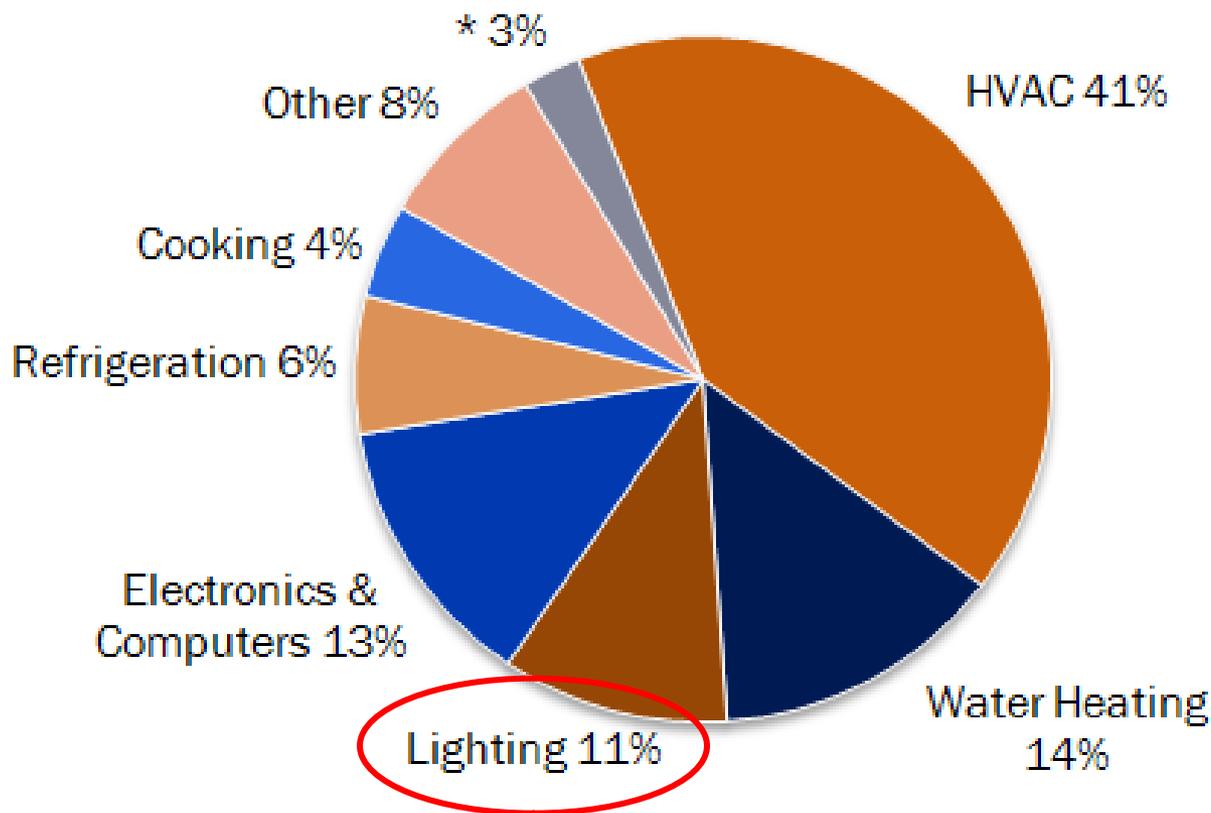
- Overview
- Technology
- Applications
- Benefits
- Summary

Is Solar Lighting Sustainable ?





Lighting Energy Use



Lighting accounts for about **11 %** of energy use in buildings.

Source: U.S. Department of Energy, 2010 Buildings Energy Data Book, Section 2.1.5, 2010. <http://buildingsdatabook.eren.doe.gov>



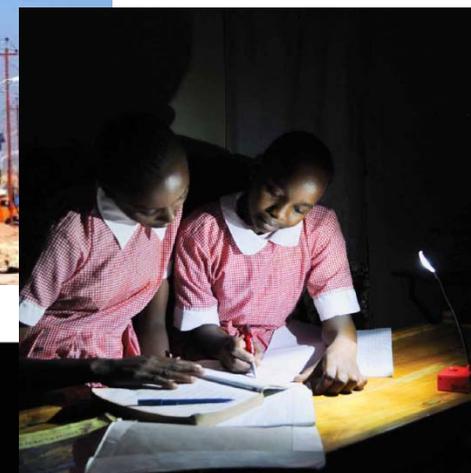
Introduction

- **Energy-saving Lighting to Zero-energy Lighting**
 - Solar LED lighting incorporate solar, LED and power storage technologies to develop not only energy saving but Zero energy consumption products.

Major Areas of Development

- There is a huge market for solar products in developing countries such as India, China, Africa and the Middle East areas with poor public infrastructure use a higher number of solar products

US and European countries are setting the standards in green building with solar energy and are starting to use more and more solar lighting products





Lighting Market

Existing Commercial Grade Lighting

Lifespan: 7-10 years
Target Customers:
Landscape architects
Lighting designers
Channel:
Project channel



Conventional

Architectural Grade

Commercial Grade Solar Lighting

Lifespan: 7-10 years
Target Customers:
Landscape architects
Lighting designers
Channel:
Project channel



Solar powered

Existing Solar LED Lighting

Lifespan: 1-2 years
Target Customers:
Home owners
Channel:
Hardware Chains (e.g.,
Home Depot, Loewe's)



Home-use DIY Grade

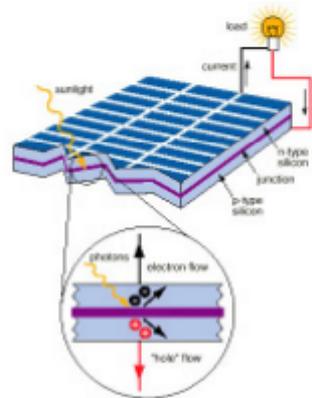


Technology

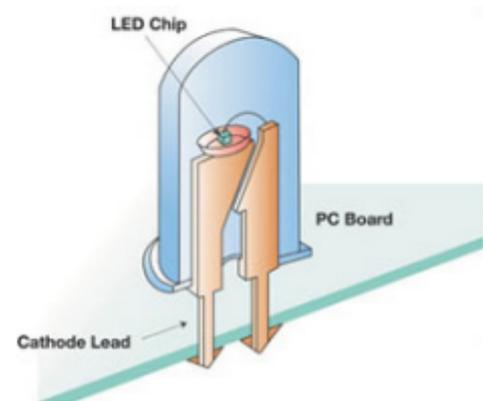


Solar & LED: Practical Applications

	PV	LED
Energy properties	Capability achieved	Energy saving
Year invented	1950s	1920s
Type of illumination	Light to electricity	Electricity to light



Source: Research Institute Sustainable En



Source: Lumileds™



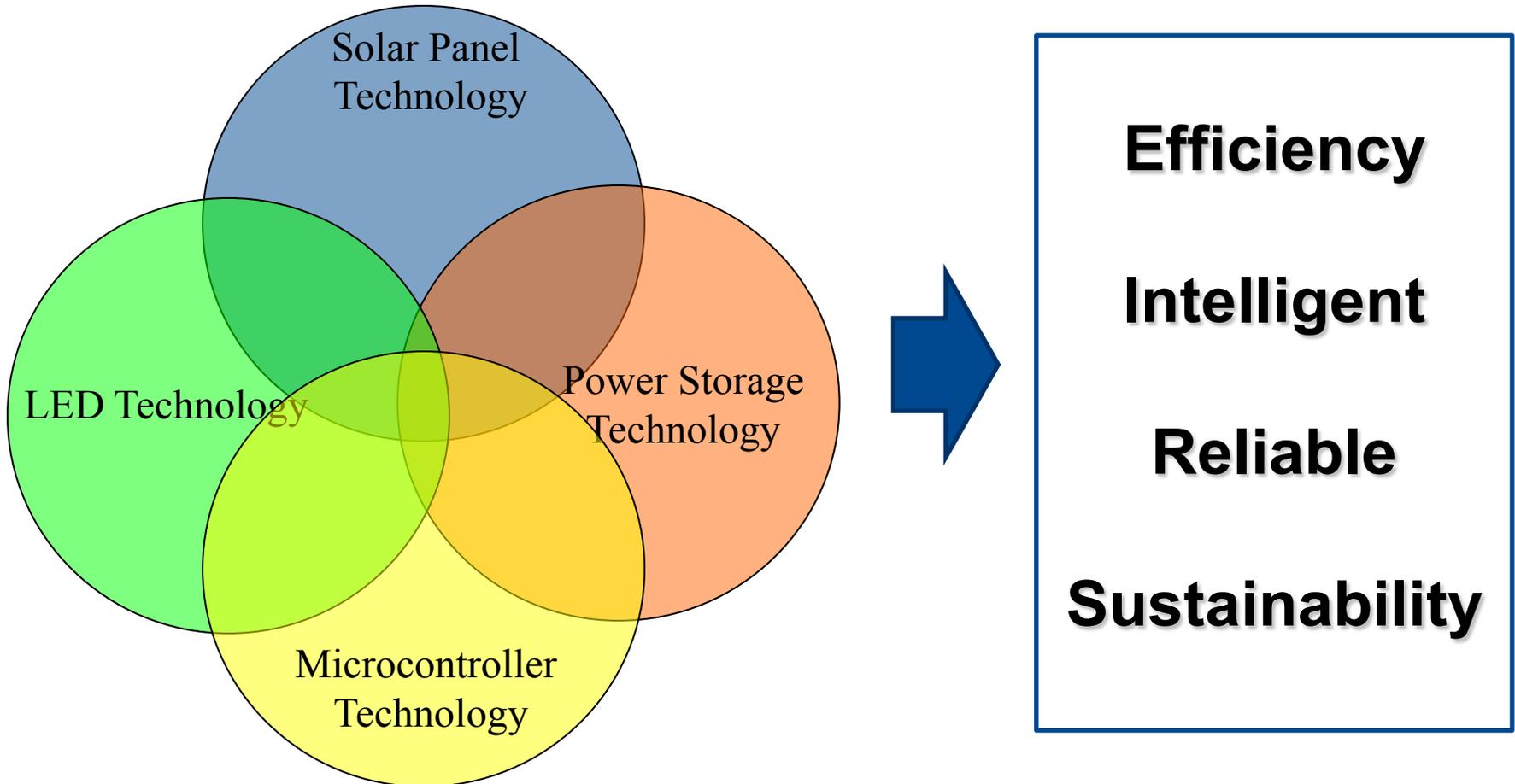
Solar & LED: Practical Applications

	PV	LED
Production/type of electrical current	DC	DC
Conversion rate/amount of current	low	low

- According to above data, it can be seen that solar power is suitable to be used LEDs for the creation of stand alone (off-grid) lighting devices.



Technology behind the Solar LED Product



Solar Panel Technologies

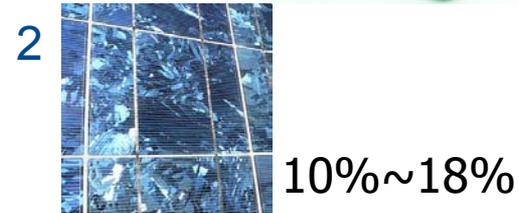
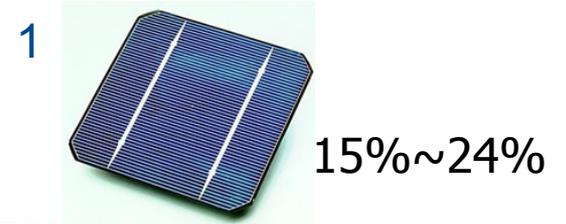
- Producers of solar lighting products are concerned with increasing the effectiveness of the solar panel--that is, how to absorb the maximum amount of solar energy with the limited space available.
- Principle methods:
 - Change solar panel type
 - Increase solar panel size
 - Incorporate solar concentrator (solar ray collector)



Solar Panel Types

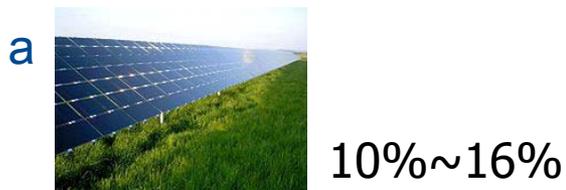
i. Crystalline Silicon

1. Monocrystalline Silicon
2. Multicrystalline Silicon



ii. Thin Film

- a. Cadmium Telluride (CdTe)
- b. Amorphous Silicon
- c. Copper, Indium, Gallium, Selenide (CIGS)



Increase surface area of solar panel

1. Solar panel on sides



Inovus



Carmanah

2. Solar panel on the top



Carmanah



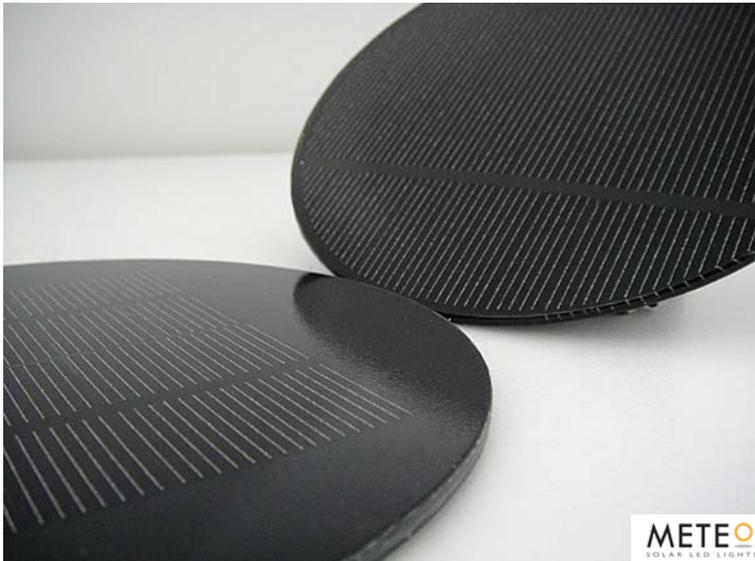
landscapeforms®

3. Advances in solar cell cutting technology



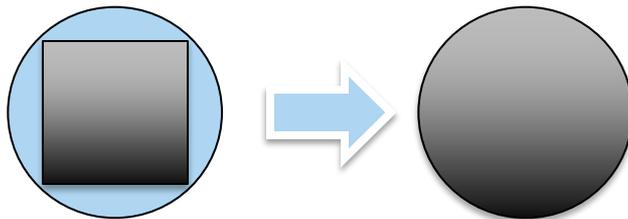


Solar Cell Cutting Technology



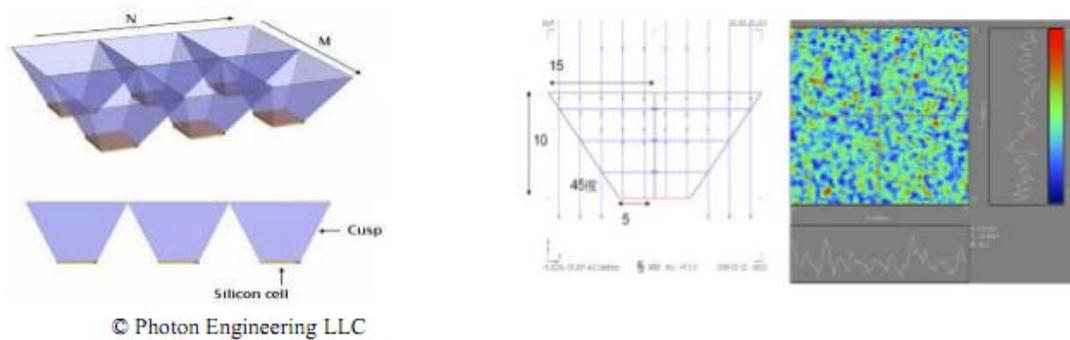
Majority of solar panels are square which places limitations on lighting design.

Incorporating advances in solar cell cutting, one can cut solar panels in any shape; thereby, increasing surface area by 50%.

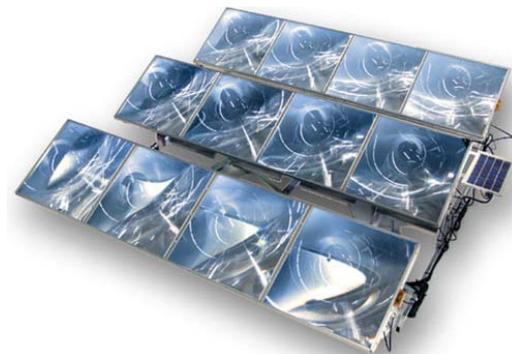


50% up

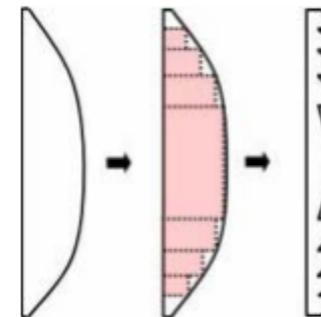
- Solar Concentrator (solar ray collector)
 - Lens Array Design



- Fresnel Lens Design



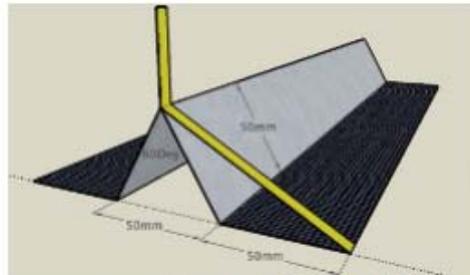
© Energy Innovations



© 2009 SPIE



- Solar Concentrator (solar ray collector)
 - Reflector Design



Homemade Solar Concentrator



Defense Industry Daily, LLC



HacknMod.com



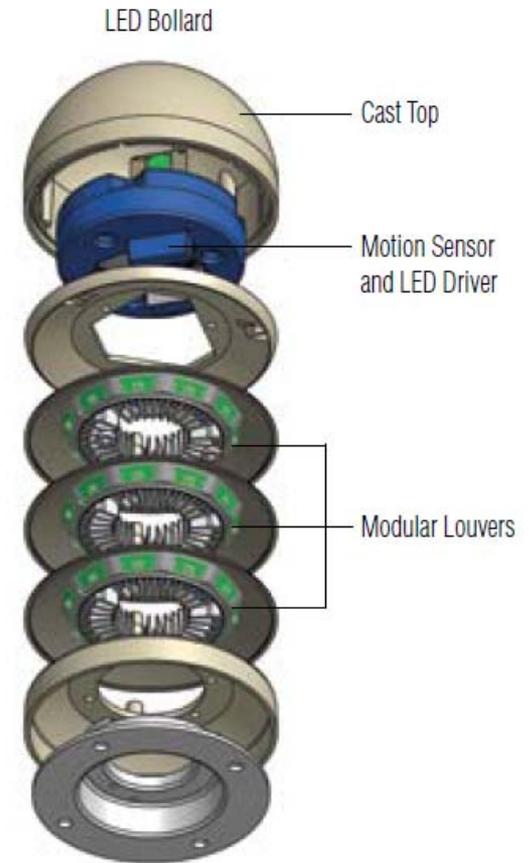
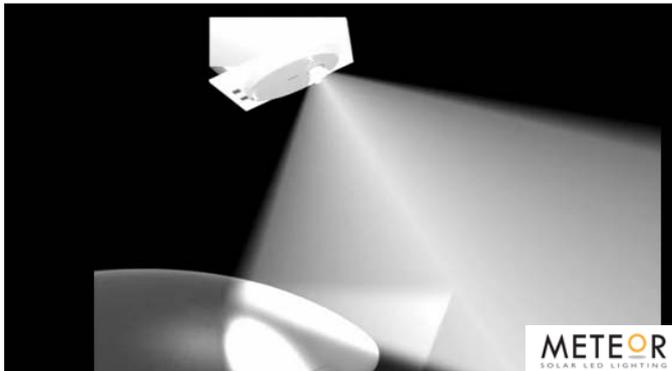
LED Technologies

- Solar panel on the market energy conversion efficiency is not very high ($< 20\%$). Manufacturers must take full advantage of the limited power when come finding the best ways to produce light.
- Below are a few ways to increase LED efficiency:
 - Optical Structure Design
 - Lens Design
 - Simulation



Optical Structure Design

- Because LED light output is very different from other light sources, we cannot use traditional lighting design concepts to design LED lights



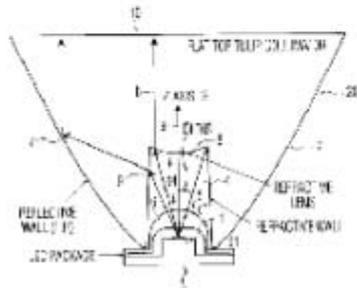
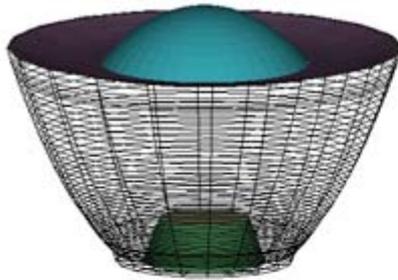
Gardco Lighting



LED Technologies

- Lens Design

Collimating
Lens Design

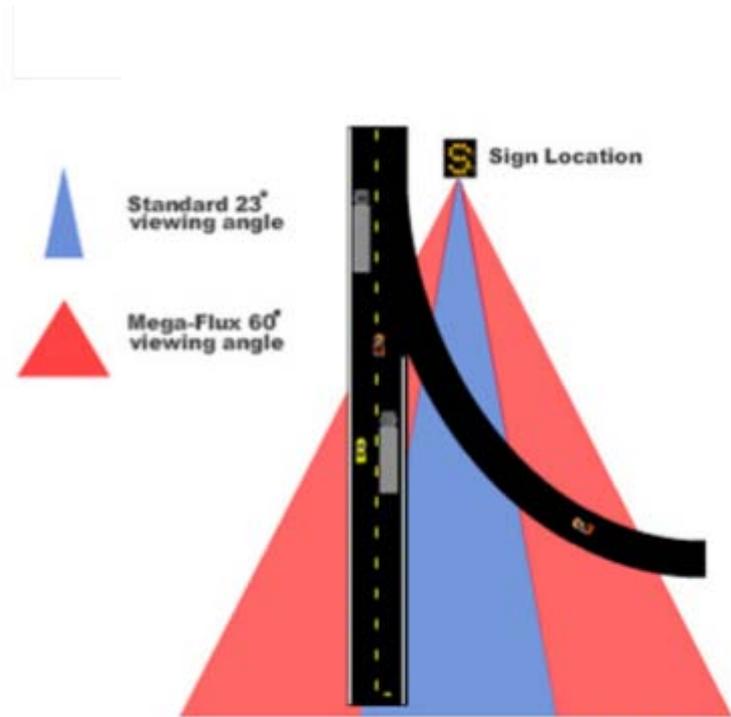
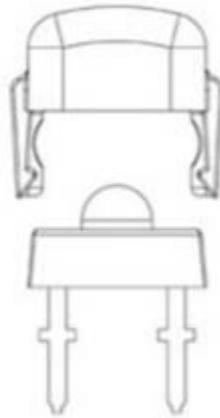




LED Technologies

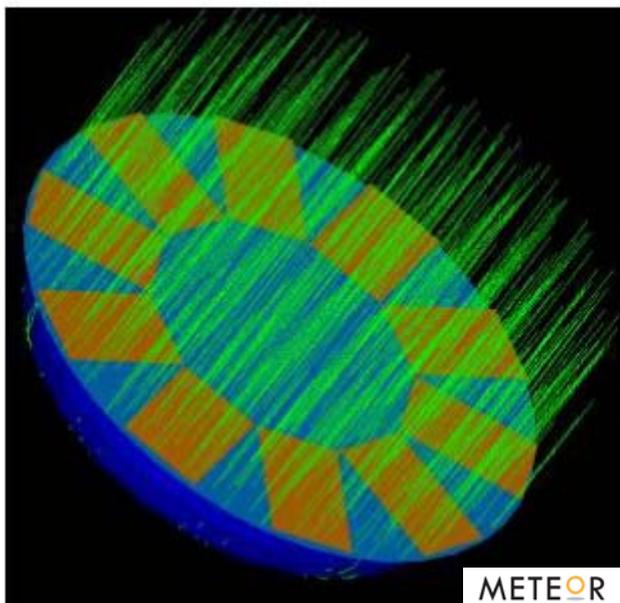
- Lens Design

Divergent
Lens Design

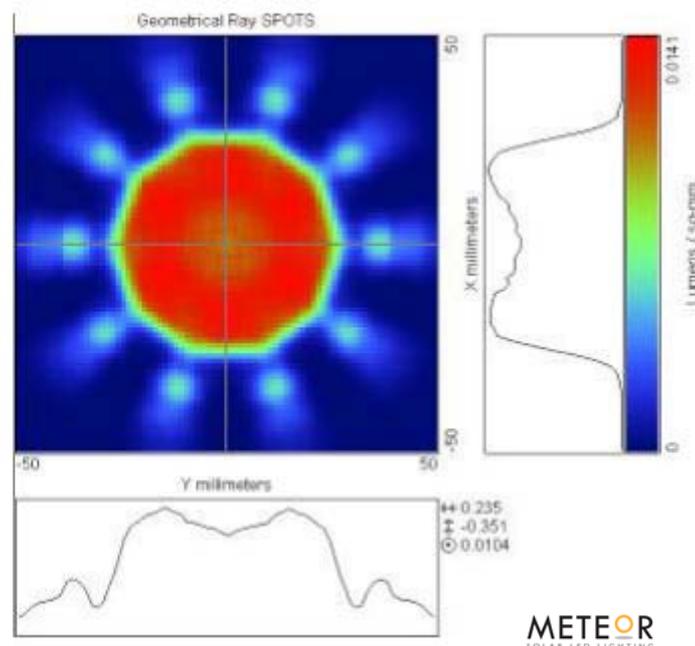


LED Technologies

- Simulation



Solar energy light gathering analysis



LED Light Model Analysis

Power Storage Technologies

- Power Storage is indeed the greatest challenge in developing solar LED lighting products today. The lifespan of Solar Panels is about 15-20 years, that of LEDs more than 10 years, but that of traditional batteries only 3 years.
- The current most effective solutions for power storage is the following:
 1. Alternative power storage solutions
 2. Power management



Power Storage Solutions

Ultracapacitor

Increases product stability and solves the most common problem of short battery life encountered by today's small-sized solar products .



Cycle life : ~10,000

Hybrid Battery

Li-Fe batteries are quite efficient. Li-Fe batteries with higher capacity are often used in hybrid electric cars.



Cycle life : ~2000

Traditional batteries

Traditional batteries must undergo power management to lengthen lifespan



Ni-MH batteries

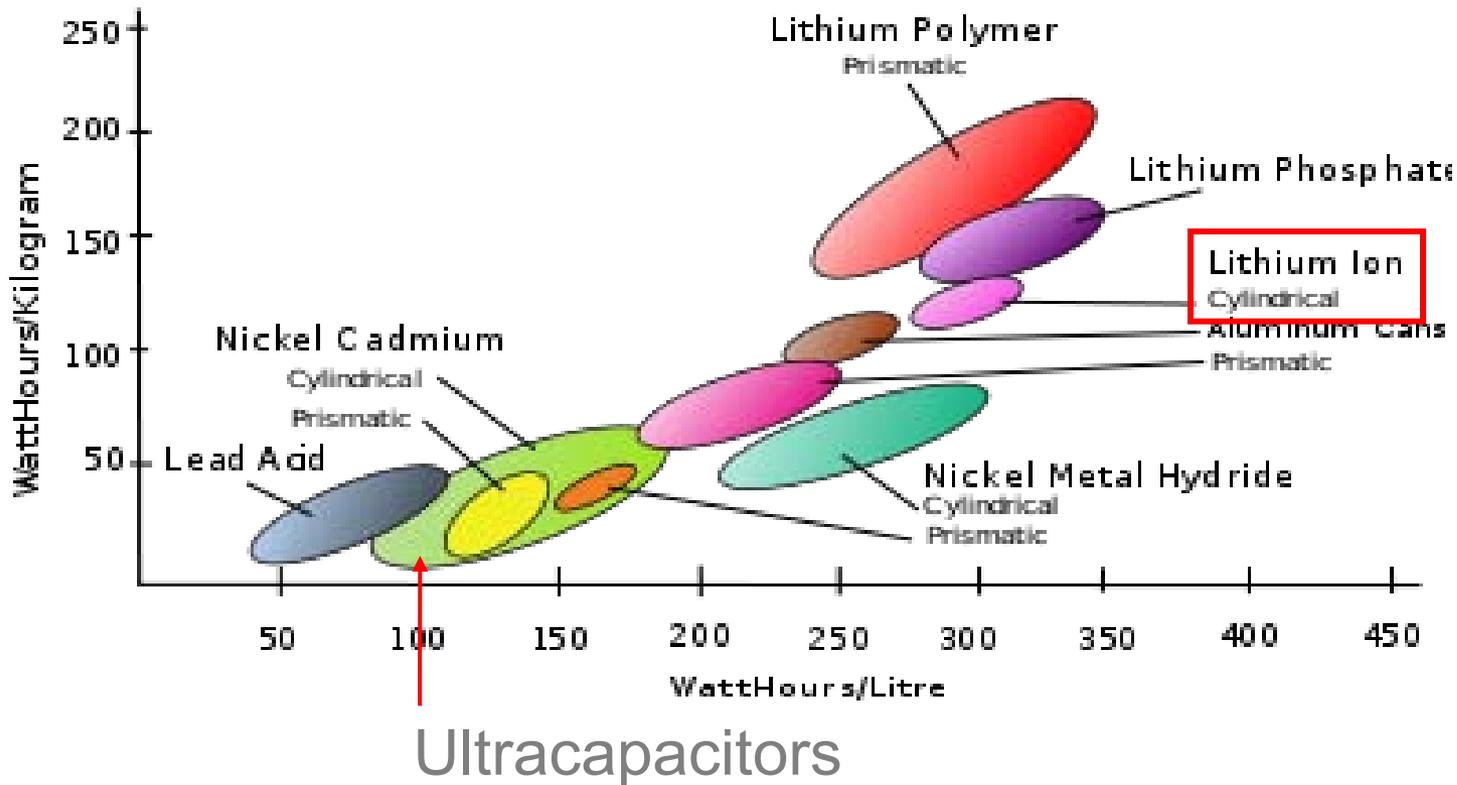
Lead-acid battery

Cycle life : 300-1000

Battery Solution



Ultracapacitor & Li-Fe Battery





Comparison of Batteries

	Lead-Acid	Ni-Cd	Ni-MH	Li-Co	LiFePO4
Energy Density(Wh/Kg)	30	57	80	167	112
Cycle life	400	500	500	>500	>2000
Working Life(Yr)	1	2	2	2	5.5
Energy Efficiency (%)	60	75	70	90	95
Self-discharging (%)	20	30	35	10	8
Safety	Average	Good	Good	Worst	Good
High Temperature Limitation	140 °F	167 °F	167 °F	149 °F	167 °F
Green Product	No	No	Yes	Yes	Yes

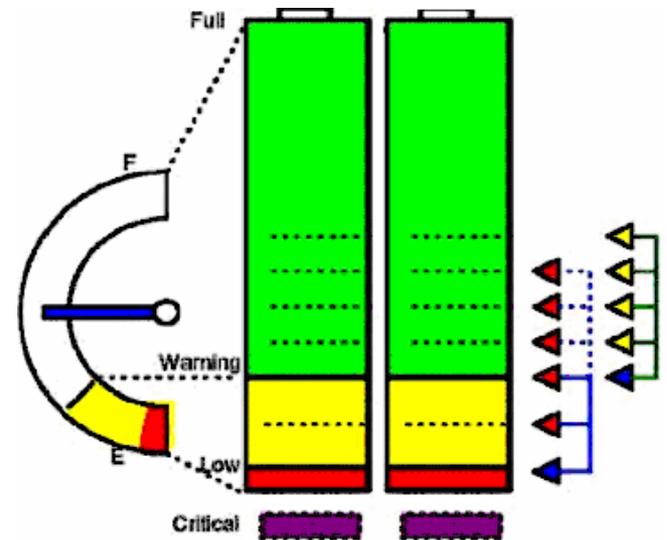


Power Management

- Effective power management

Features

- Minimize energy effect
- Increase battery capacity
- Lengthen battery lifespan



Battery Capacity Management



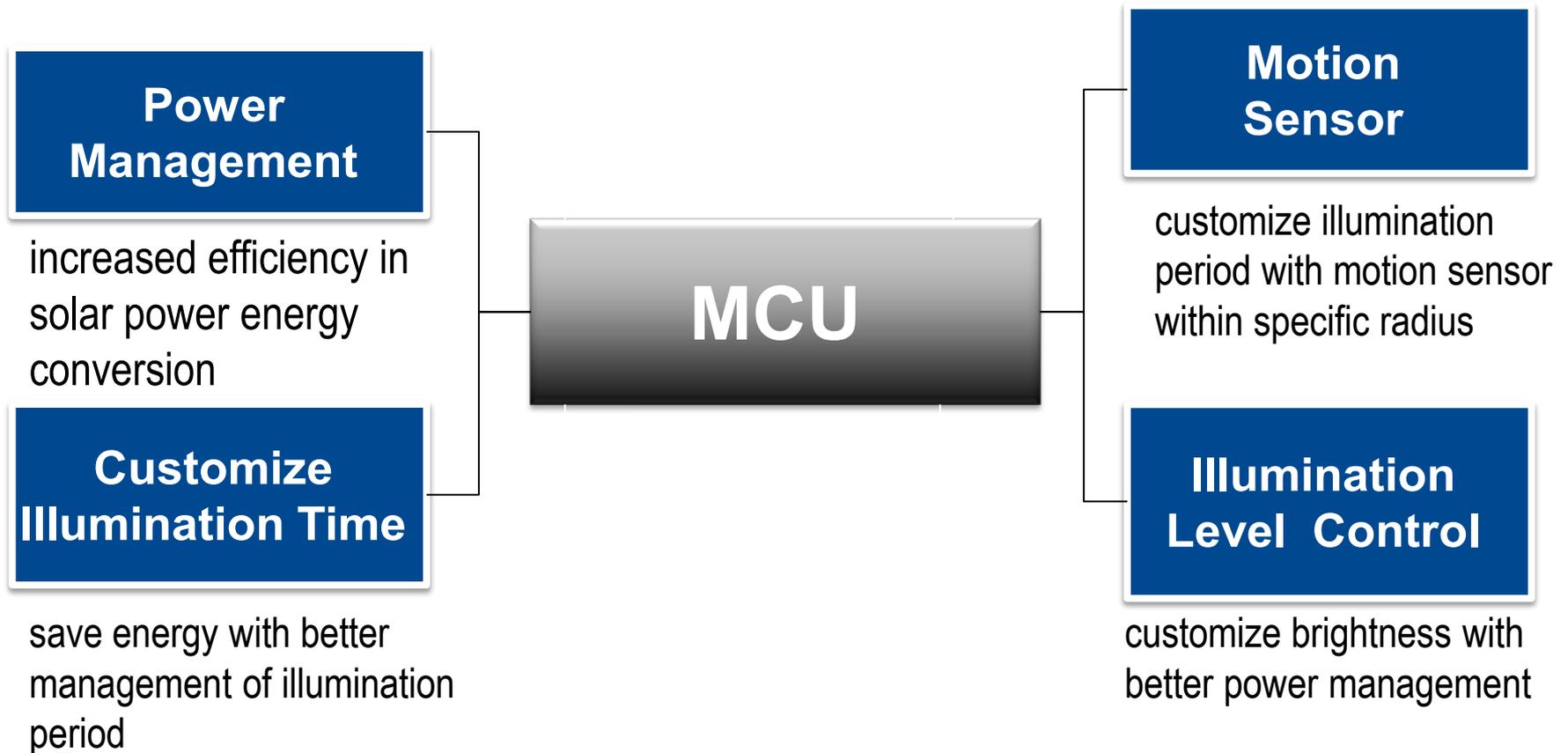
Technological Advancements

- With precise power management capabilities, Meteor will equip future solar designs with microcontrollers (MCU) to serve performance-critical roles.
- MCUs are also ideal for
 - Increasing efficiency of solar power
 - Increasing LED illumination efficiency
 - Extending battery life





MCU (Micro Controller Unit)





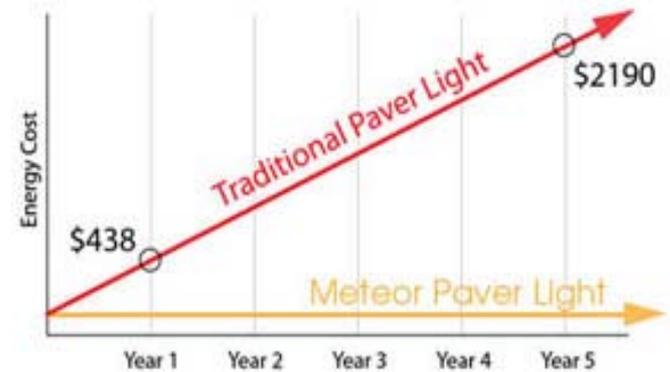
Solar Lighting Benefits

Save on Installation

Conventional Paver/Ground lights	METEOR Solar LED Paver/Ground lights
Maintenance	Maintenance
Transformer	Transformer
Wiring	Wiring
Labor Cost	Labor Cost
Installation	Installation

[Maintenance and Installation Cost Saving]

Save on Utilities



Save the Planet





Application

| **Campuses**

| **Driveways**

| **Walkways**

| **Streetscapes**

| **Gardens**

| **Landscaping**

| **Plazas**

| **Entrances**

| **Malls**

| **Sidewalks**

| **Courtyards**

| **Building facades**





Solar Decathlon

- Since 2009, Meteor has been the first and sole lighting sponsor at the Solar Decathlon
- In 2009, in line with the patriotic theme, we installed over 100 red, white, and blue solar LED paver lights on the thoroughfare of the National Mall
- This year, over 80+ solar LED bollards are installed throughout the solar village





Summary

- Solar lights are not low end products
- Bigger solar panel enables brighter illumination
- Power storage is the key to longer lifespan
- Microcontroller makes the lights smarter and more efficient
- Solar lights offer consumers with a win-win solution



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SOLAR DECATHLON

Time to shine.

A nighttime photograph of a grassy field with several illuminated solar lights. The lights are cylindrical with a glowing white band. In the background, there are trees and some distant lights, suggesting an outdoor setting at dusk or night.

**Thank you
for your time !**