

U.S. DEPARTMENT OF ENERGY



# SOLAR DECATHLON 2009

## Solar at Night

## Solar LED Applications

Minson Lu

Meteor Solar LED Lighting

U.S. DEPARTMENT OF  
**ENERGY**



National Renewable  
Energy Laboratory  
Investment in Our Energy Future



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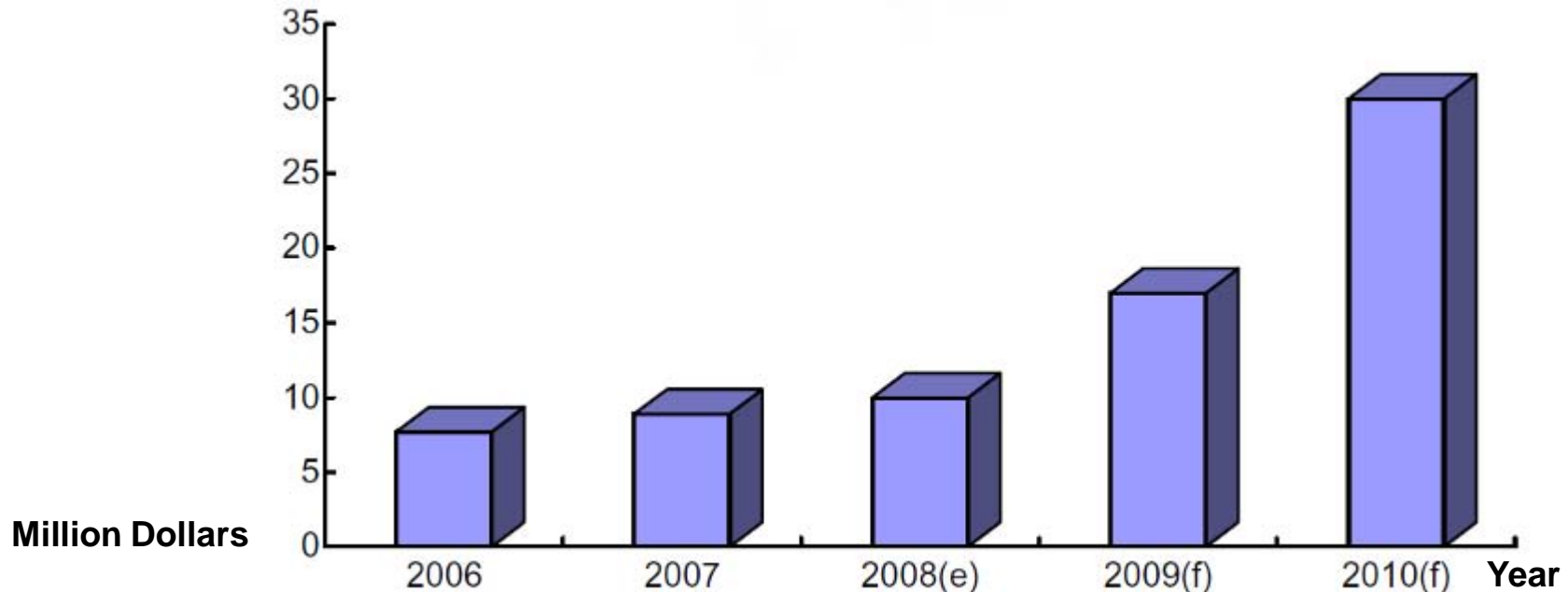


# Introduction

- Following the trend for the utilization of alternative energy sources, solar energy has experienced explosive growth. Even so, at this point in time, from the point of view of economic efficiency, the production cost of solar energy is quite high. This is why solar power sources are often integrated with energy efficient LED lighting products.
- Market forecasts predict that by the year 2010, LED lighting market will surpass 30 million and the predicted growth rate from 2006-2010 will reach **20%-30%**.



## Off-grid Solar LED Lighting Market



Source: Strategies Unlimited





# Major areas of development

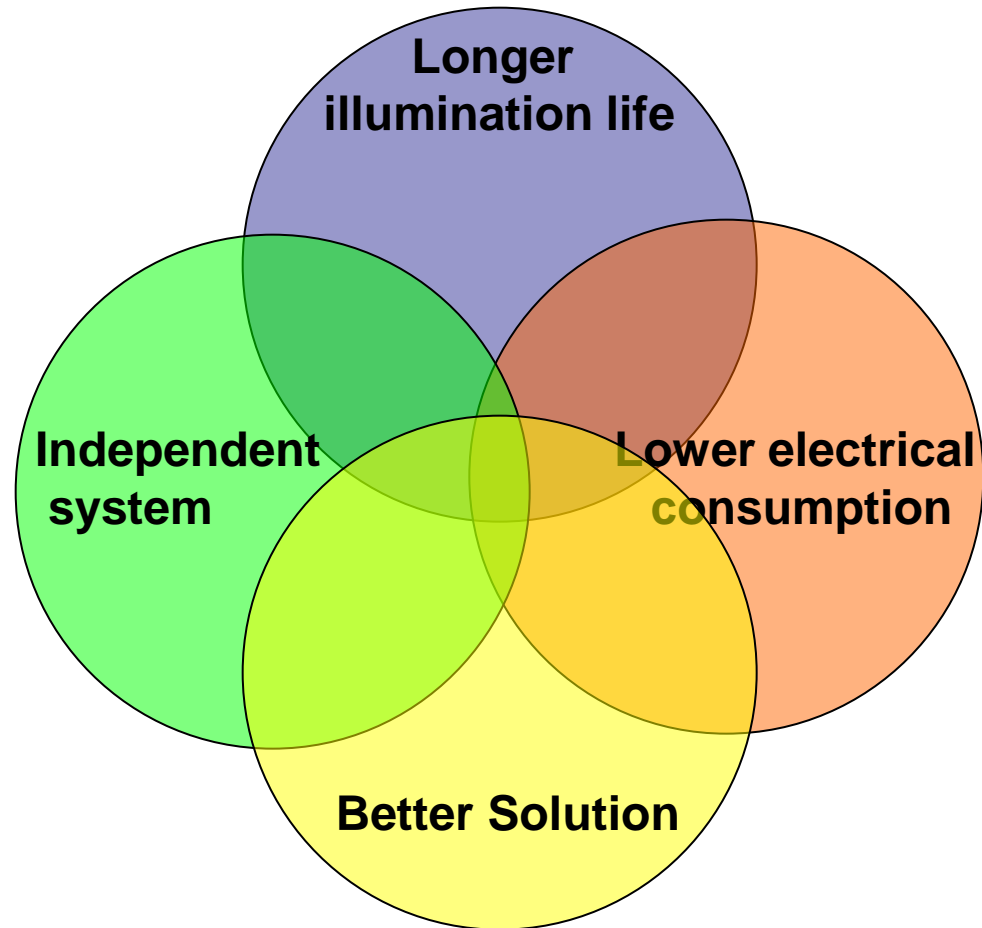
Generally speaking development is occurring more rapidly in the US and Europe. However, some suppliers also market solar powered LED lighting products to 3<sup>rd</sup> World countries or developing countries such as India and in the Middle East. Areas with a lack of public infrastructure use a correspondingly larger number of solar products.





## How to design a good Solar Product

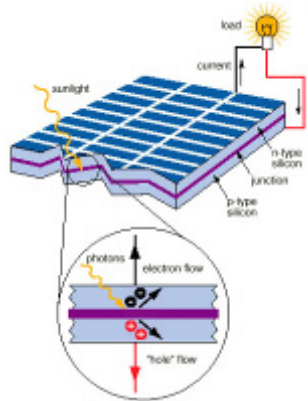
- Good Solar Product should have four important features.



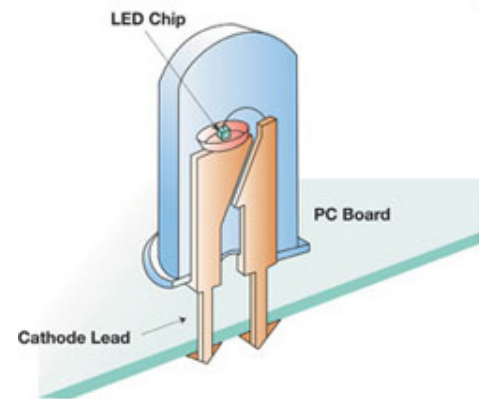


## Solar VS LED: practical applications

	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 VS LED: practical applications

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

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



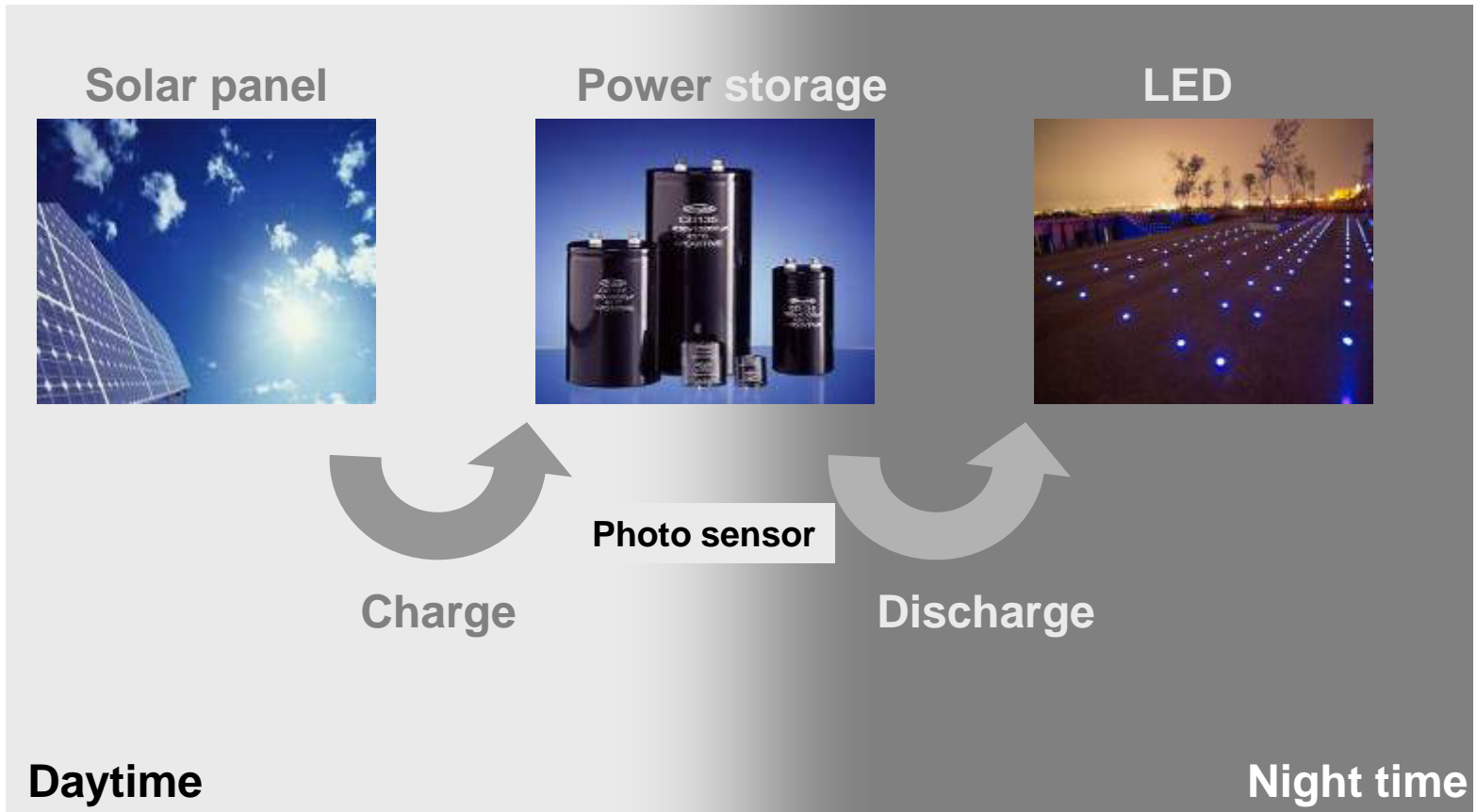


# How it works

- Self-contained solar powered LED lighting systems (off-grid) work by absorbing solar radiation in the daytime, which is converted to electrical energy by passing through the power converter. This energy stored in a storage device. At night the controller allows the stored power to be released to illuminate the LEDs. It is safe to say that the solar power–LED light combination is an optimum model for energy efficient alternative lighting solutions.



## How it works





## Technologies

- Solar LED Applications: the most important technologies involved are shown below

**Solar Panel Technologies**

**LED Technologies**

**Power Storage Technologies**





# Solar Panel Technologies

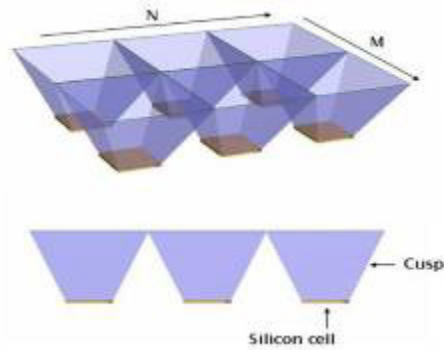
- Producers of solar lighting products are concerned with increasing the effectiveness of the solar panel--that is, how to absorb the maximum amount of solar energy with the limited space available.
- The principle application methods include:
  - Increasing the size of the solar panel
  - Solar Concentrator



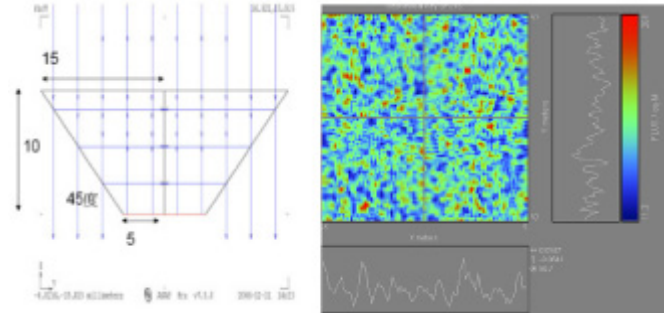
## Solar Panel Technologies

- Solar Concentrator

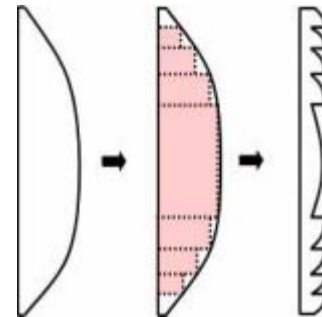
Lens Array Design



© Photon Engineering LLC



Fresnel Lens Design



© 2009 SPIE

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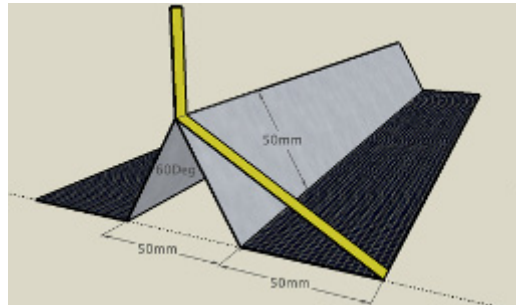




## Solar Panel Technologies

- Solar Concentrator

Reflector Design



Homemade Solar Concentrator



Defense Industry Daily, LLC



HacknMod.com



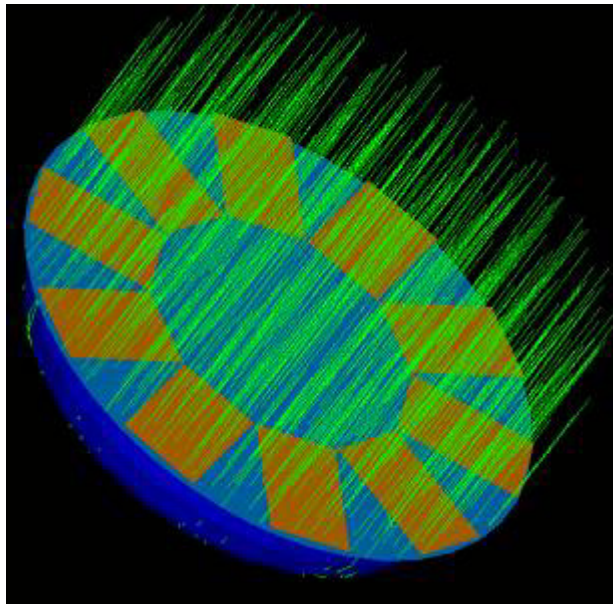
# LED Technologies

- The energy conversion efficiency of Solar Panels is not large. Manufacturers must take full advantage of the limited power when come finding the best ways to produce light.
- At the present time the assistance of optics design software helps to make product design easier.

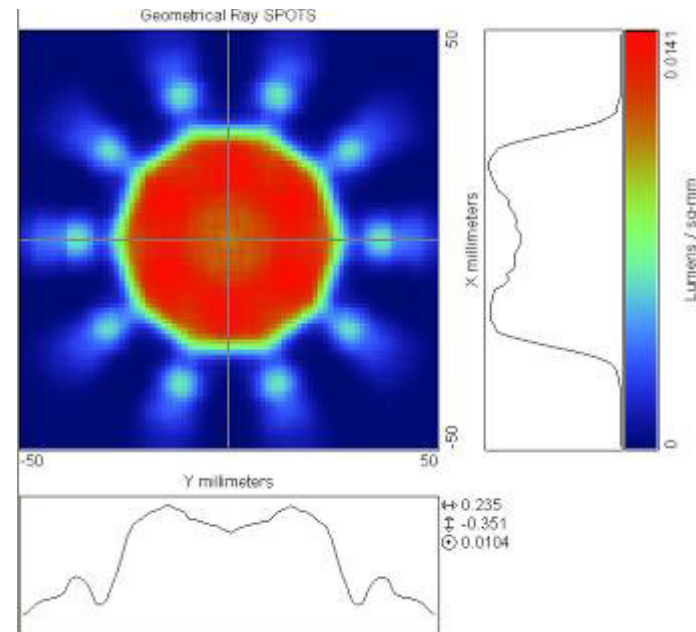


## LED Technologies

- Optical Design



Solar energy light gathering analysis



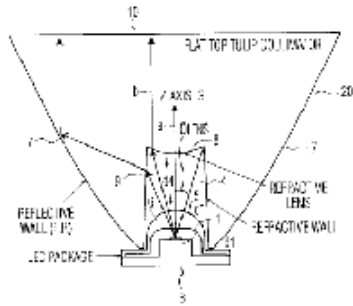
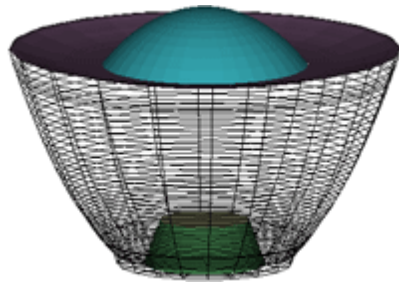
LED Light Model Analysis



## LED Technologies

- Adjusted Control of Light Distribution

Collimating  
Lens Design



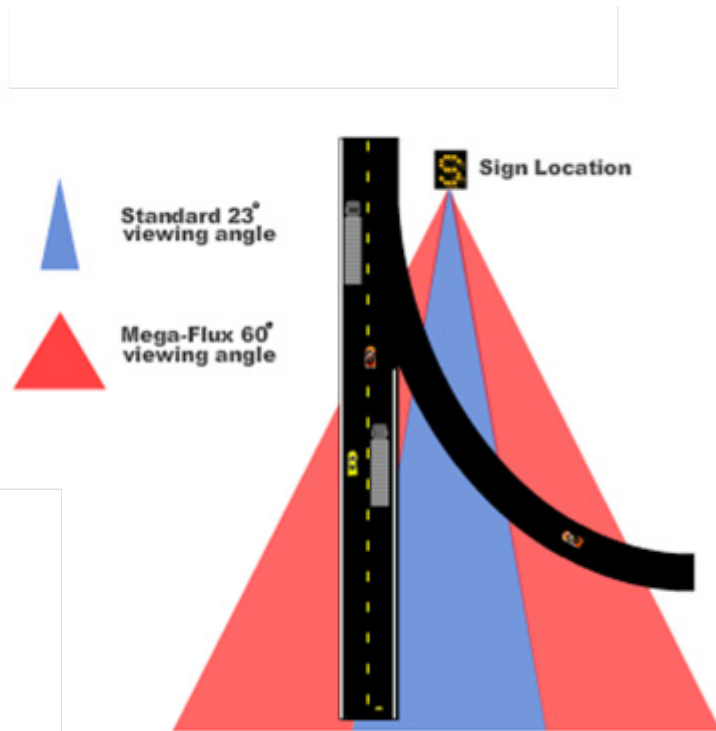
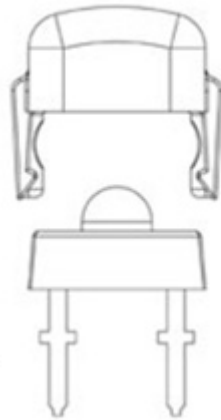




## LED Technologies

- Adjusted Control of Light Distribution

Divergent  
Lens Design



© Solar Technology





# Power Storage Technologies

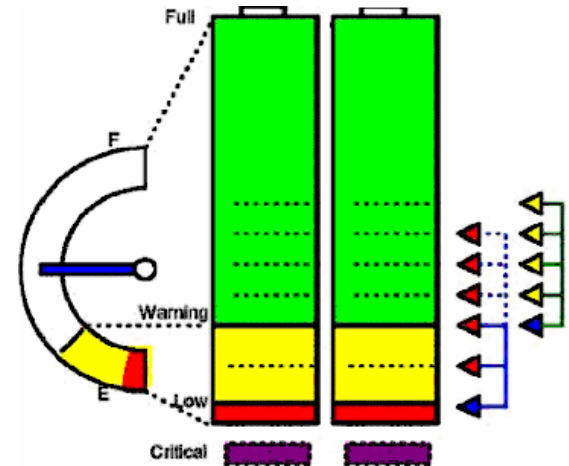
- Power Storage is indeed the greatest challenge faced in developing solar LED Lighting products. The lifespan of Solar Panels is about 15-20 years, that of LEDs more that 10 years, but that of traditional batteries only 3 years.
- The current most effective solutions are:
  - Advanced Charge Circuit Design
  - Ultracapacitor



## Power Storage Technologies

- Optimized Charge Circuit Design

- The special circuit design reduces the frequency of the discharge of the storage device, thereby avoiding producing the memory effect. In addition the use of high quality devices extends the service life of the storage device.





# Power Storage Technologies

- Ultracapacitor
  - Not only does the use of the ultracapacitor increase product stability, but it also solves the most common problem encountered with today's small-sized solar products:  
**Short Battery Life.**
  - At the present time, ordinary batteries last about 2 years, but the ultracapacitor increases the battery life to **7-10 years.**



## Power Storage Technologies

- Comparison between Batteries and Ultracapacitors

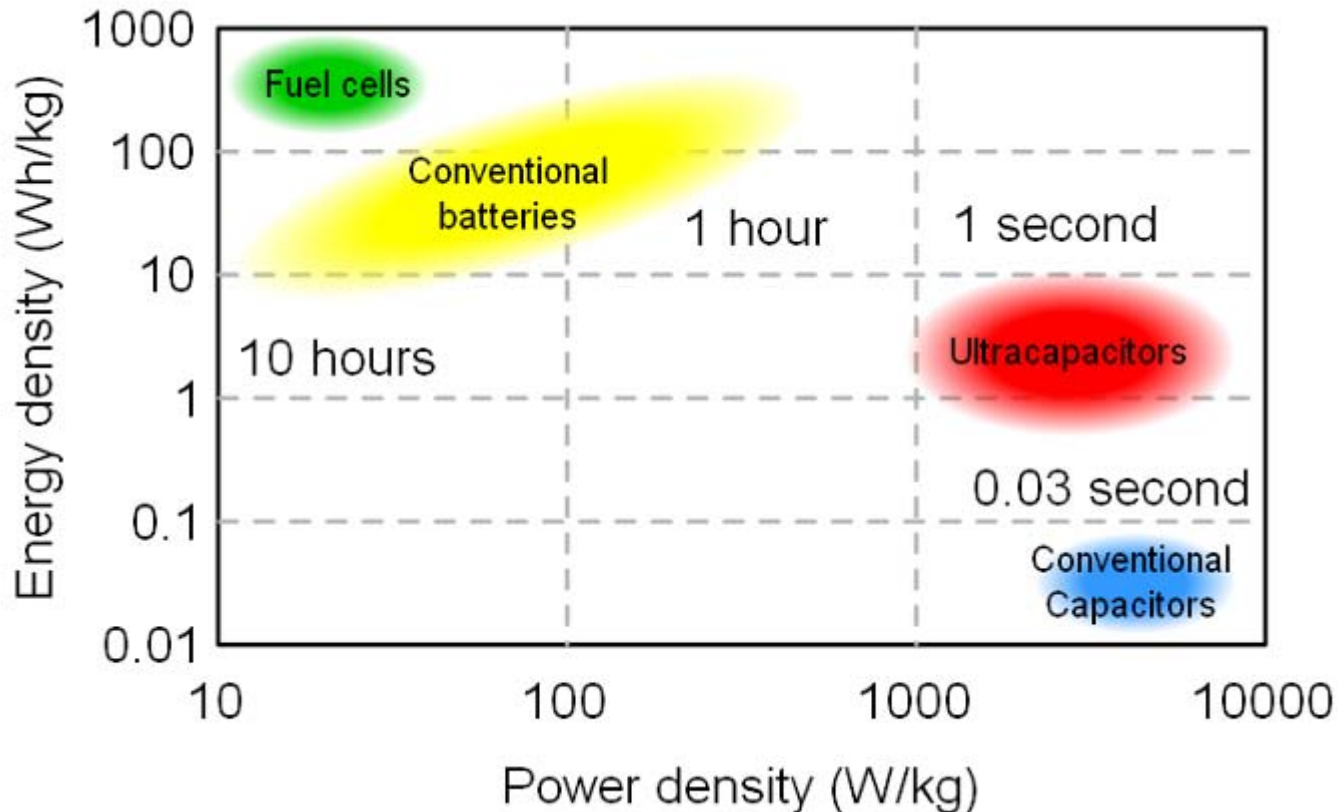


	Battery	EDLC
Cycle Life	200~1000	>>100000
Life-Time	2~3 years	7~10 years
Discharge Curve		



## Power Storage Technologies

- Comparison between Batteries and Ultracapacitors







## Applications

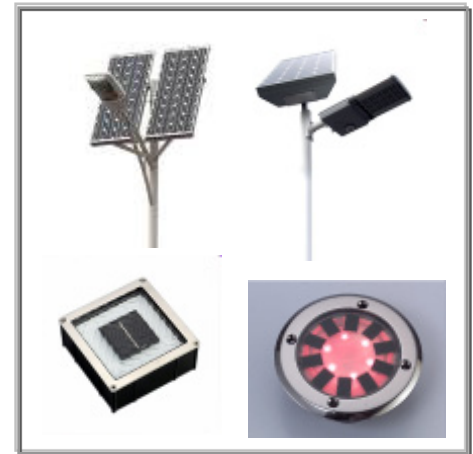
### Safety



### Landscape



### Construction





## Application

- Safety
  - Sign
  - Beacon
  - Warning light





## Application

- Landscape (DIY Product)
  - Garden Light
  - Functional DIY Lighting





## Application

- Construction
  - Solar Street Light
  - Solar Paver / Ground Light





# Solar LED Products Demo



# The End

Thank you for your attention.

