



*Photovoltaics History and  
Technology  
Prepared for the National Parks Service  
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May, 2002*

***Solar Electricity:  
The Reliable, Economical, Clean  
Distributed Power Solution***



***Photovoltaics (PV) vs. other solar - PV converts sunlight directly into electricity***



***Distributed  
Solar  
Thermal***



***Centralized  
Solar Thermal***

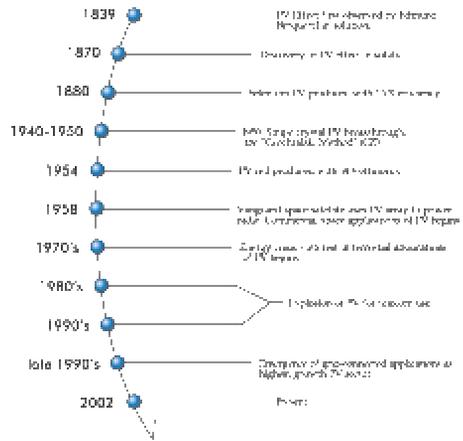


***Photovoltaics***

***Topics Covered***

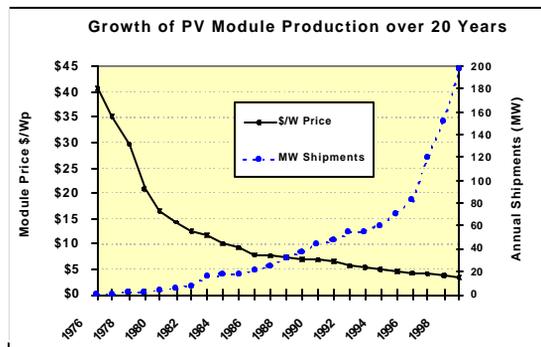
- History of Photovoltaics
- PV Technology Basics
- Commercial Grid-Connected Systems
- Benefits of on-site PV generation

## PV History Timeline



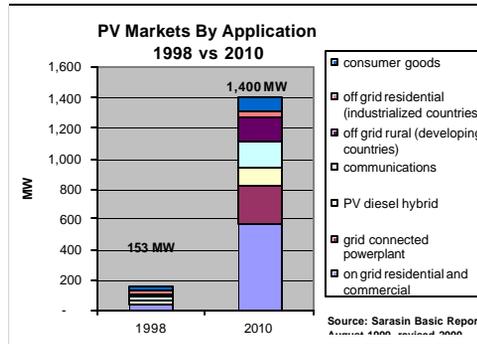
### History of PV

**PV prices have fallen 10x in the last 25 years**



History of PV

**Grid-connected systems are now the fastest growing segment of the PV market**



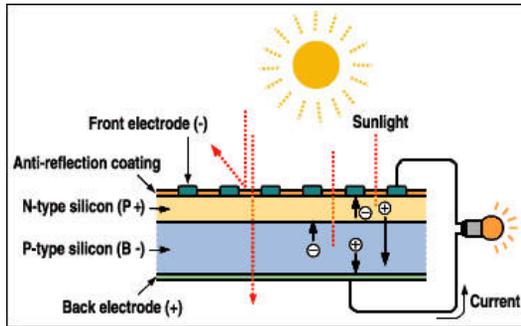
30%+ growth per year forecasted

History of PV

**Who uses commercial PV systems today?**

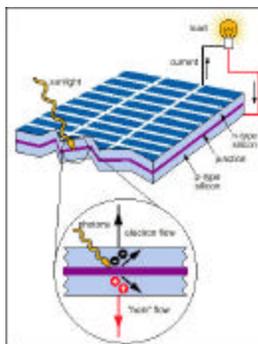


*Photovoltaic Basics*  
**PV Technology Fundamentals –  
“The Photovoltaic Effect”**



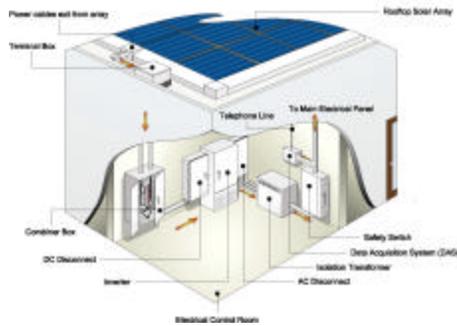
Sunlight excites electrons in the solar cell and creates electric current

*Photovoltaic Basics*  
**PV cells are connected together to form a module**



*Commercial Grid-Connected Systems*  
**Basic components of a commercial grid-connected solar system**

**Solar Electric Array Flowchart**



*Commercial Grid Connected Systems*  
**Traditional methods of mounting PV on flat, commercial rooftops are problematic**



**Conventional attachment**



**Ballast tray**

*Commercial Grid Connected Systems*

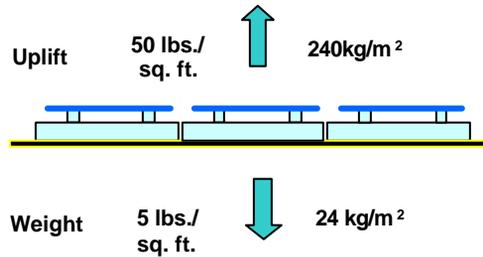
***PowerLight provides the best mounting solution for commercial PV installations***

- Patented
- Lightweight
- No penetration
- Insulates roof
- Protects roof
- Pre-engineered
- UL listed



*Commercial Grid Connected Systems*

***Lightweight and wind resistant***



*Commercial Grid Connected Systems*  
***Palletized shipping and lifting***

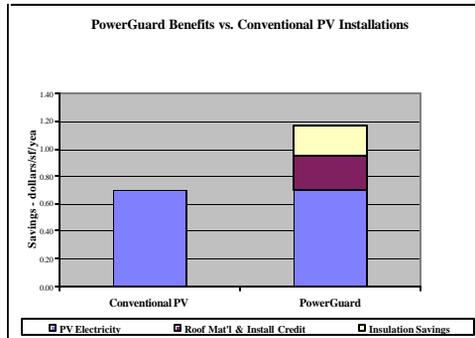


*Commercial Grid Connected Systems*  
***Fast non-invasive installation***

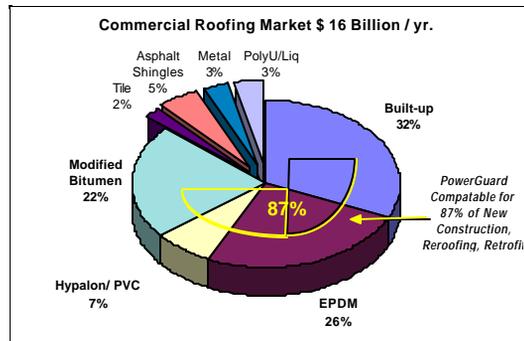


**Commercial Grid Connected Systems**  
**Value advantage of PowerLight rooftop systems**

**Benefits vs. conventional mounting**

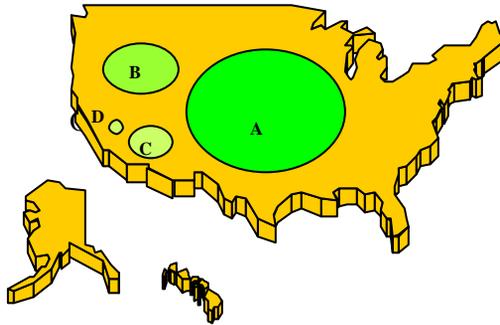


**PowerGuard®**  
**Compatible with 87% of existing US roofs**



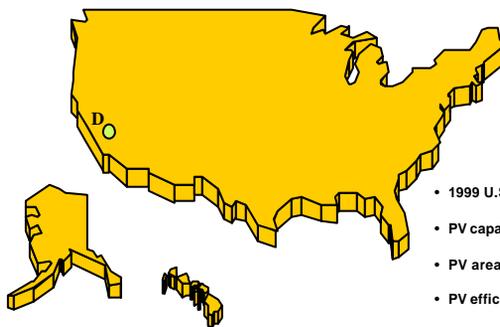
*Commercial Grid Connected Systems*

**What area of PV is required to satisfy 100% of US electrical energy needs?**



*Commercial Grid Connected Systems*

**Area D: PV in a 45-mile radius would serve total US electric energy needs**



- 1999 U.S. energy use  
3,500 TWh/yr
- PV capacity  
2.2 TW
- PV area  
6,600 sq. mi.
- PV efficiency  
12%

Sources: USEIA

***Why the National Park Service Chose to Implement  
a Solar Electric System***

**Financially prudent**

- 1) Zero fuel costs
- 2) Financial hedge against fuel price increases
- 3) Coincident with expensive “peak” electricity

**Reliable**

- 1) Proven technology
- 2) 20 to 25 year warranties on electricity generation
- 3) Virtually maintenance-free

**Clean**

- 1) Zero emissions
- 2) 100% renewable
- 3) Over-the-counter permitting

**Safe and Silent**

***Yosemite Solar Project Summary:***

**Project Size:** 47 kWp, 350 solar electric rooftiles covering approximately 4,500 square feet of the NPS’s El Portal Maintenance Facility

**Turnkey Contractor:** PowerLight Corp.

**Product:** *PowerGuard* solar rooftop tiles

**Generates enough electricity to power more than 45 homes**

**Reduces National Park Service’s peak energy consumption by 10%**

**Environmental savings:**

1,508 tons of carbon dioxide over 25 years  
950 lbs of Nox over 25 years  
25 lbs of SO2 over 25 years

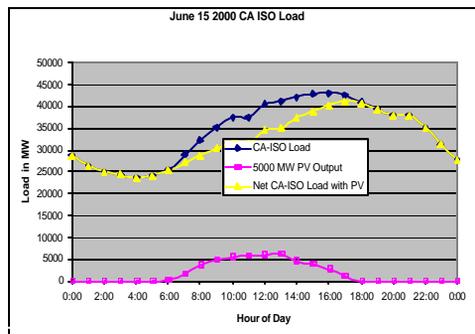
**Project Economics:** 11% IRR or 11 year payback

**National Park  
Service  
El Portal, CA  
Maintenance  
Facility**

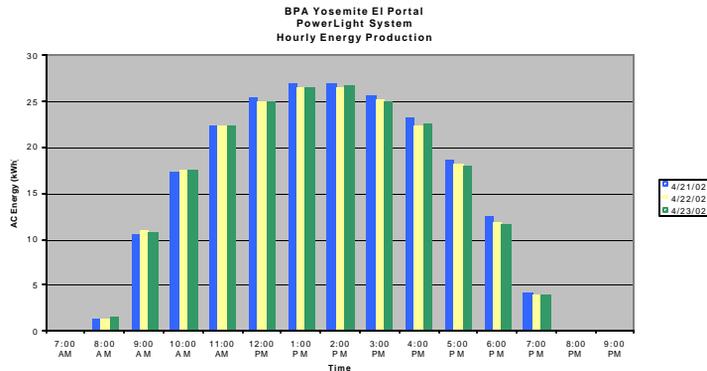
**47kWp  
PowerGuard  
solar  
electric roof  
system**



**Benefits of onsite PV generation  
PV is coincident with peak-power  
demand, and shaves system peaks**



**Benefits of onsite PV generation**  
**PV is a reliable, proven technology,**  
**with highly predictable energy output**



**Benefits of onsite PV generation**  
**PV is the cleanest energy technology**  
**available. The El Portal system will save:**

**25 Year Lifetime Predicted Energy: 1,331,065 kWh**

**Offset emissions:** 1,500 tons of CO<sub>2</sub> (smog, acid rain)  
 950 lbs Nox  
 25 lbs SO<sub>2</sub>

**Equivalent to:** Planting trees: 17 acres  
 Not driving 3,770,000 miles

*PV System Economics*

***Total system economics has several components***

- **Geographic location of the system**
  - 1) Amount of sun available
  - 2) Electricity rates, especially daytime and summer
  - 3) Local PV incentives
- **Savings from total-system benefits**
  - 1) Reduction in electricity costs
  - 2) Extended roof life
  - 3) Thermal efficiency benefits
- **Net system cost**
  - 1) Initial system cost
  - 2) Maintenance costs (virtually none)

*PV System Economics*

***Financial services***

- **Design most cost-effective payment structure**
  - 1) Purchase, when all tax benefits can be used
  - 2) Loan, up to 100% financing
  - 3) Tax lease, cost-effective if tax benefits cannot be used by owner
  - 4) Host system & purchase electricity (3rd-party ownership), more complex. Feasible only in certain states
- **Considerations**
  - 1) Source of funds. Operating vs. capital budget
  - 2) Cash flow

***Questions to consider for on-site solar***

- **How much solar can your real estate support (flat or sloped roofs, parking lots, open land)? 10,000 sq. ft. or more**
- **What is your annual electricity consumption in kWh?**
- **What is your annual electricity cost?**
- **What is your cost per peak kWh?**
- **Do you have solar incentives in your State?**