



U.S. Department of Energy
Energy Efficiency and Renewable Energy

DOE Tribal Energy Program California Workshop Solar Electric Technologies Photovoltaics (PV)

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January 23, 2008



Photovoltaics (PV)



Photovoltaics directly convert sunlight into Direct Current (DC) electricity.





Two Broad Categories of Solar Electricity Generation

Distributed Generation (On-Grid PV)

- Energy is generated at the point of use
- Displaces electricity
- Energy is valued at avoided retail prices



Concentrating Solar Power (CSP)

- Large plants under dispatch control
- Utility or independent ownership
- Energy distributed by utilities
- Energy valued at wholesale prices





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Building-Integrated PV (BIPV)



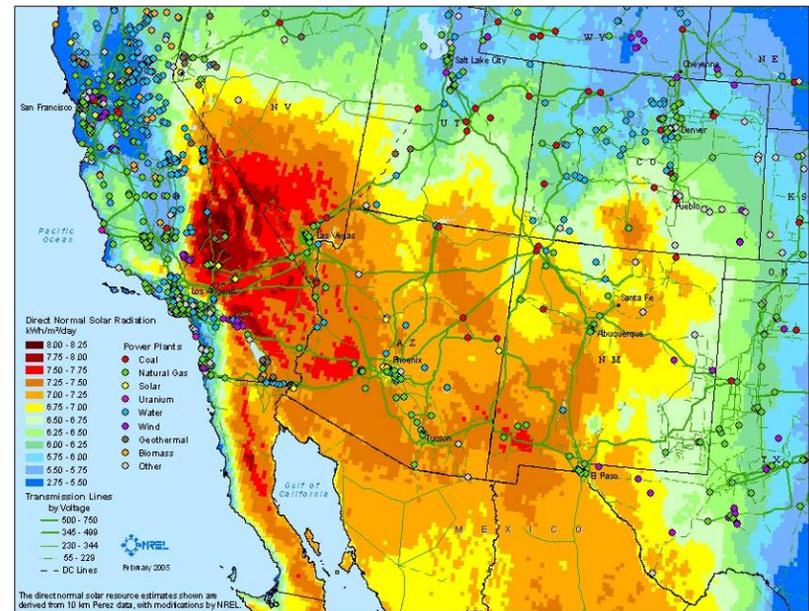


Solar Resource in the US Southwest

Screening Approach

Filters applied:

- Direct-normal solar resource.
- Sites $> 6.75 \text{ kWh/m}^2/\text{day}$.
- Exclude environmentally sensitive lands, major urban areas, etc.
- Remove land with slope $> 1\%$.



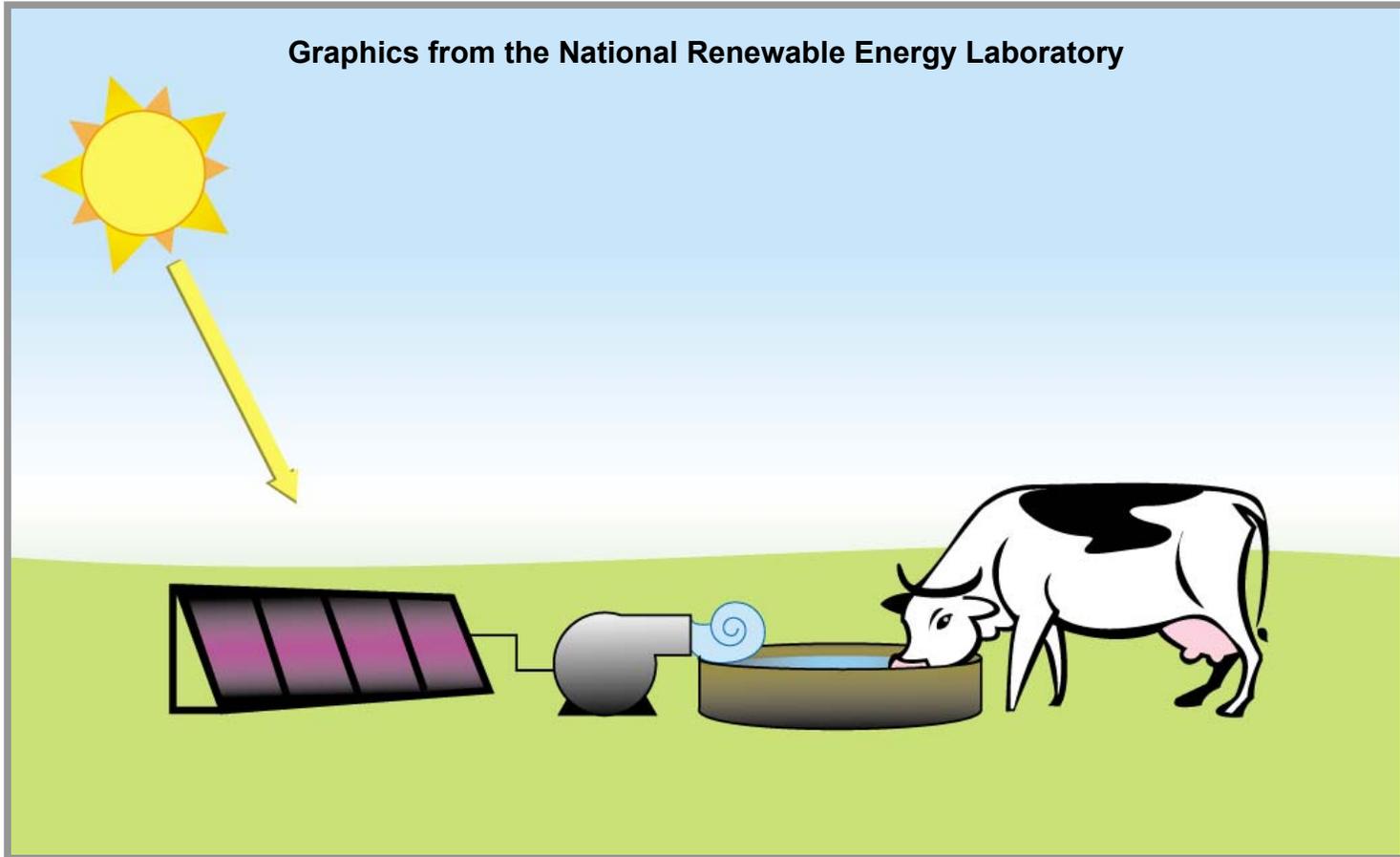
Data and maps from the Renewable Resources Data Center at the National Renewable Energy Laboratory



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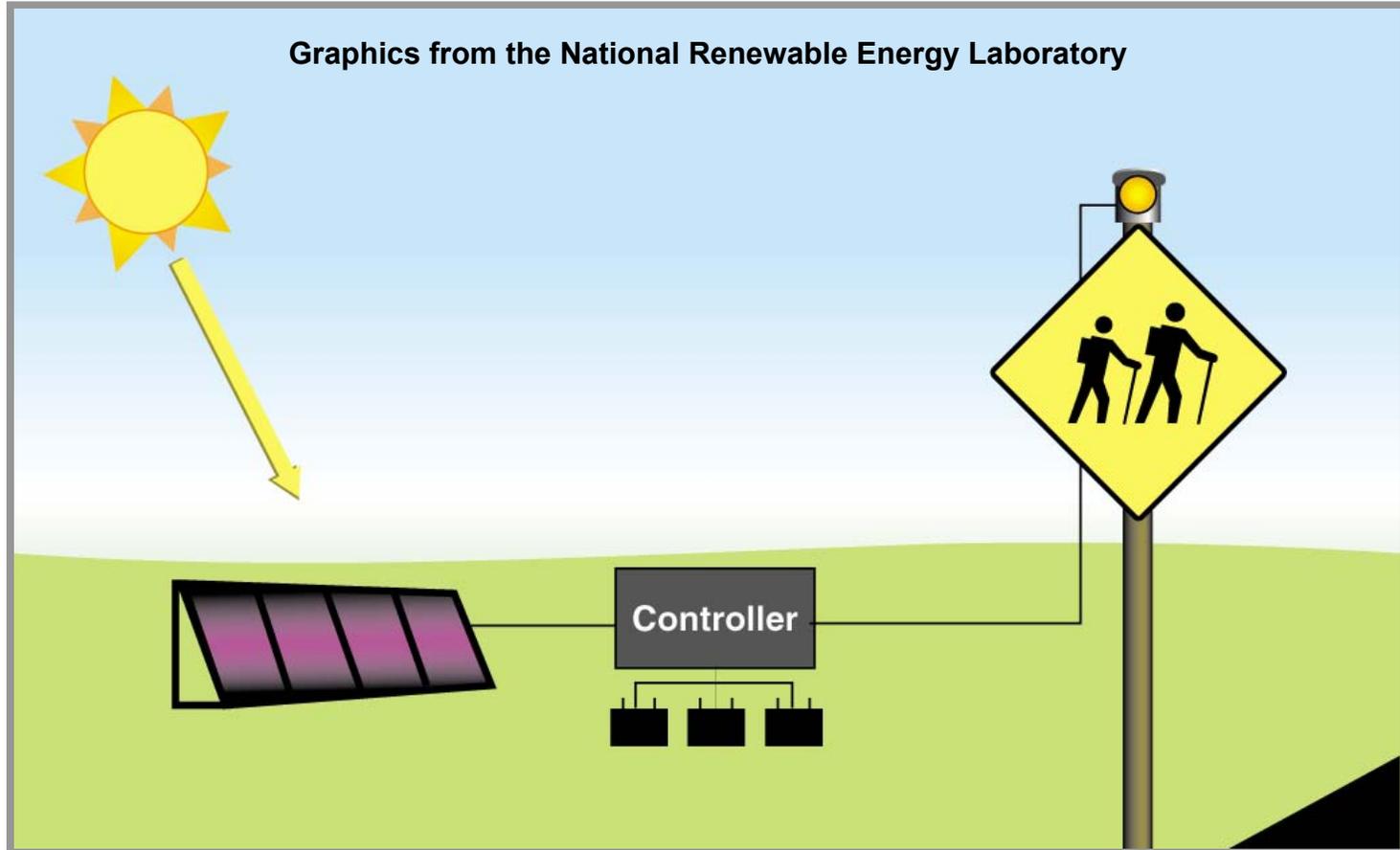
Simple Direct Drive PV System

Graphics from the National Renewable Energy Laboratory



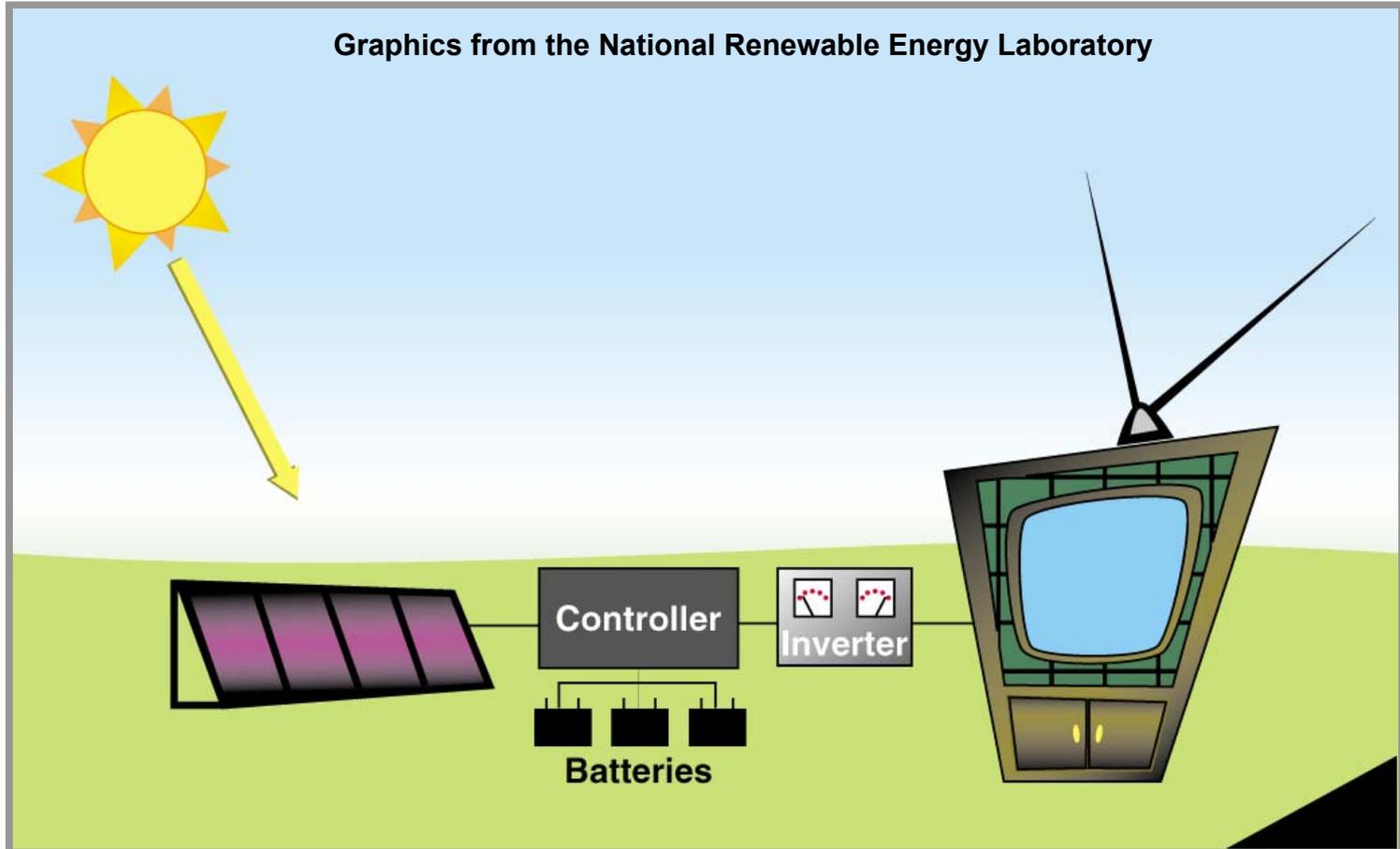


Simple DC PV System with Battery Storage



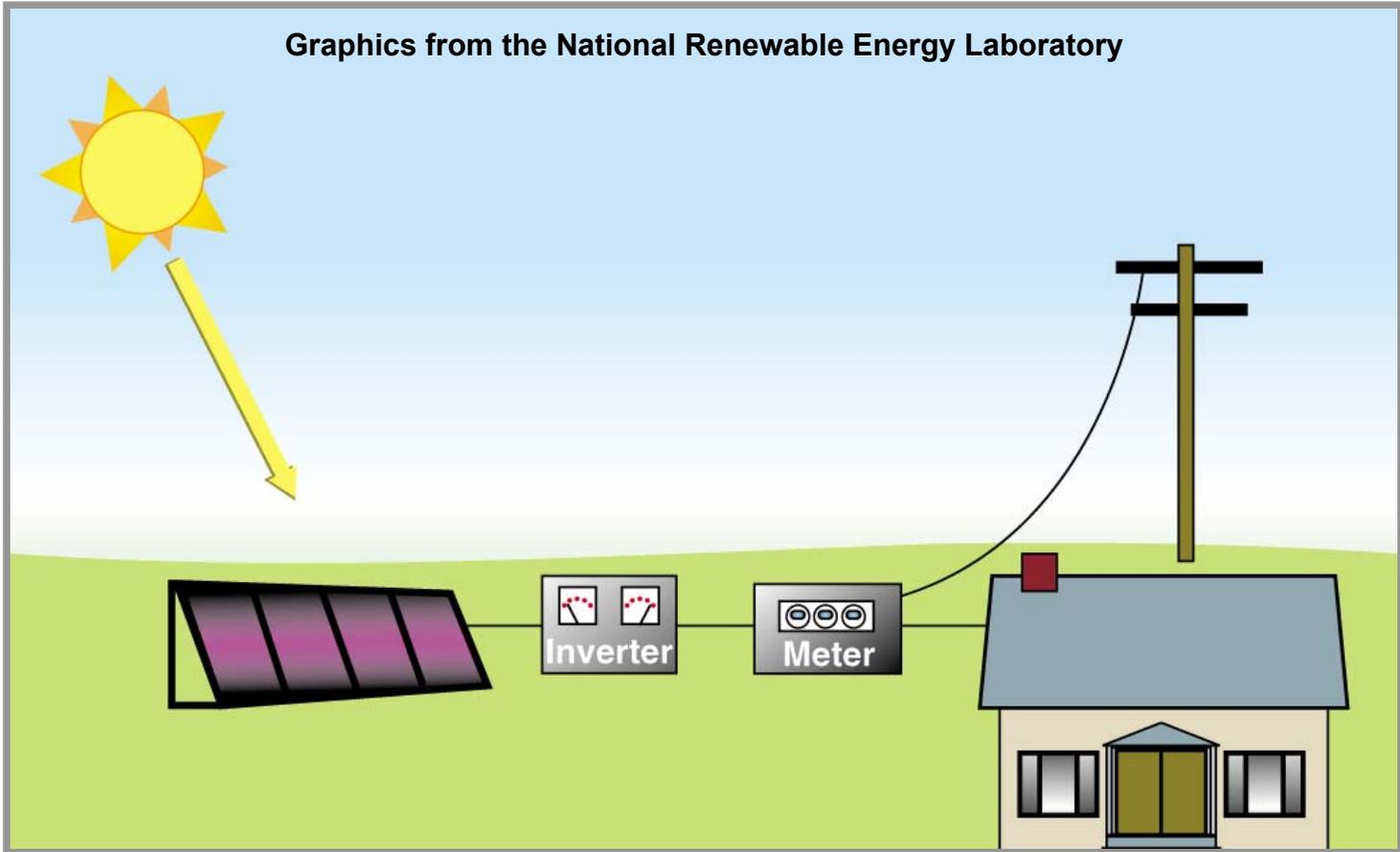


AC PV System with Inverter





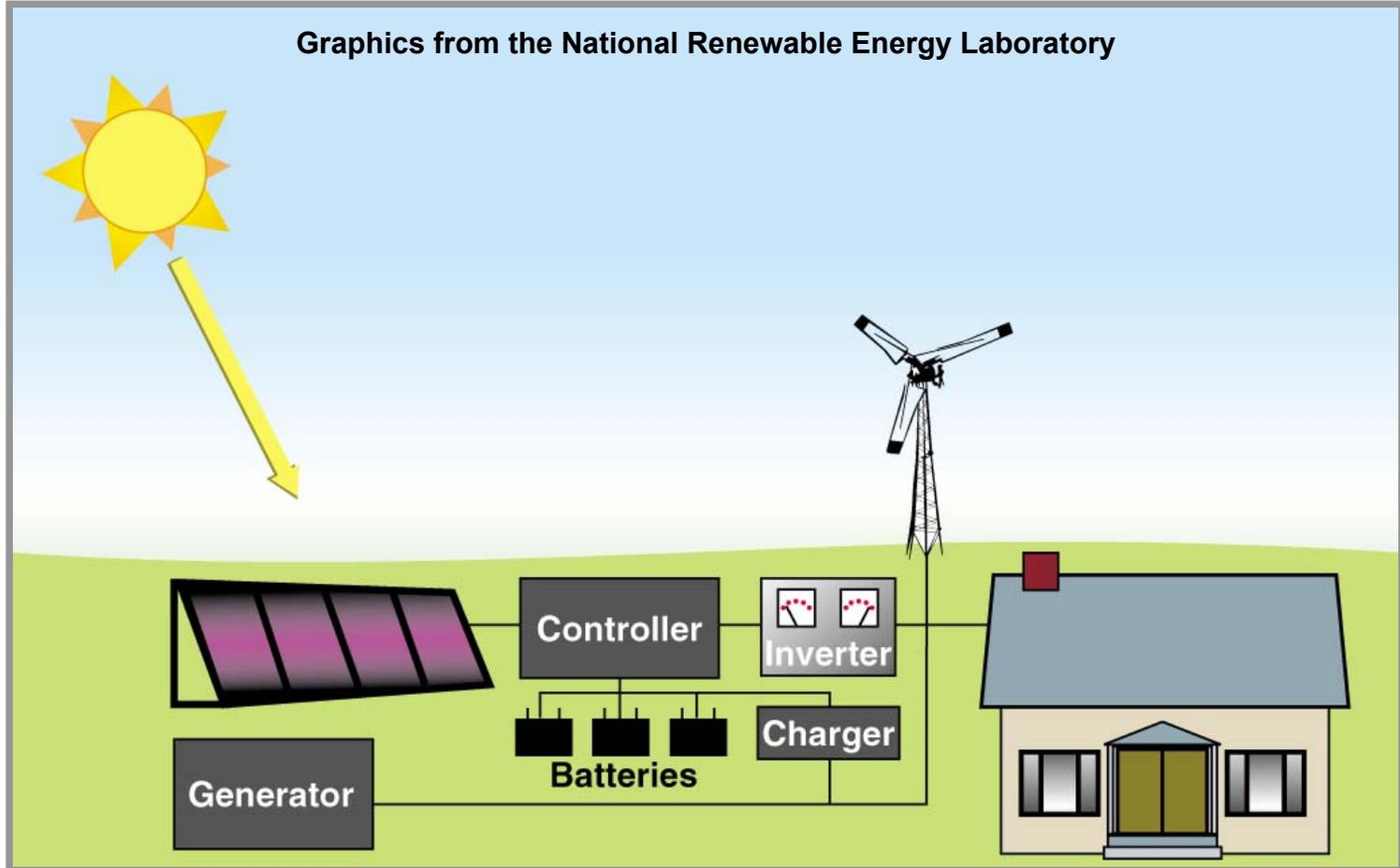
Utility-Connected (Grid-Tied) PV System





Hybrid PV/Generator System

Graphics from the National Renewable Energy Laboratory



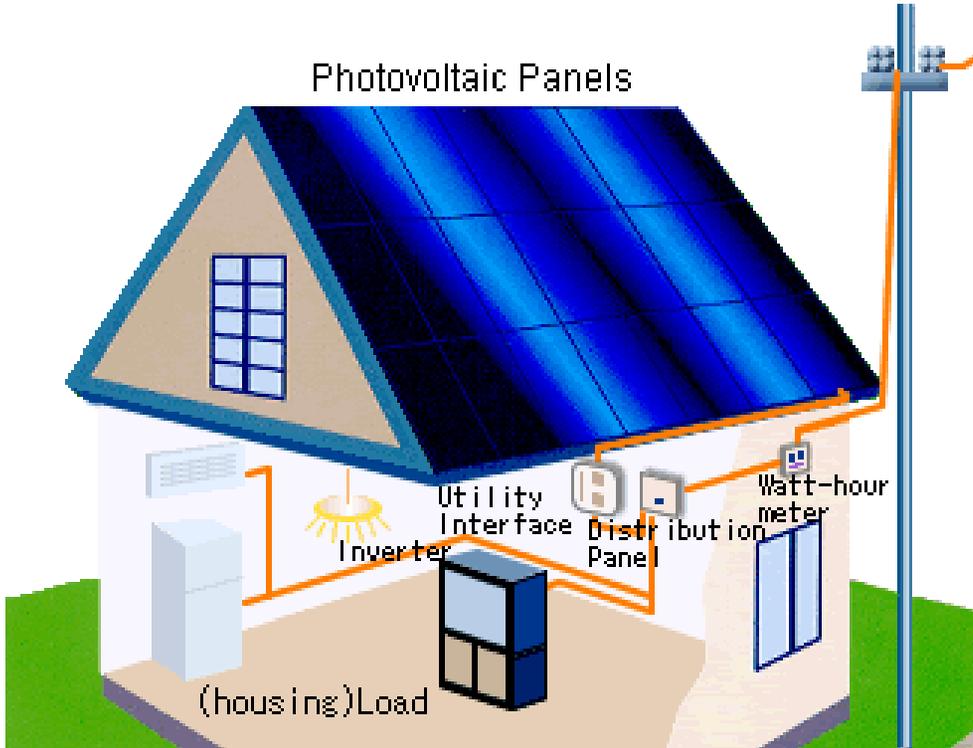


Simple PV house system

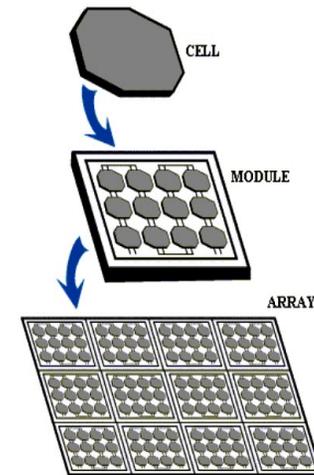
[RPT]

AC Power Supply

Photovoltaic Panels



- System
- Array
- Inverter
- Utility Interface/Control
- Meters
- Storage batteries (optional)

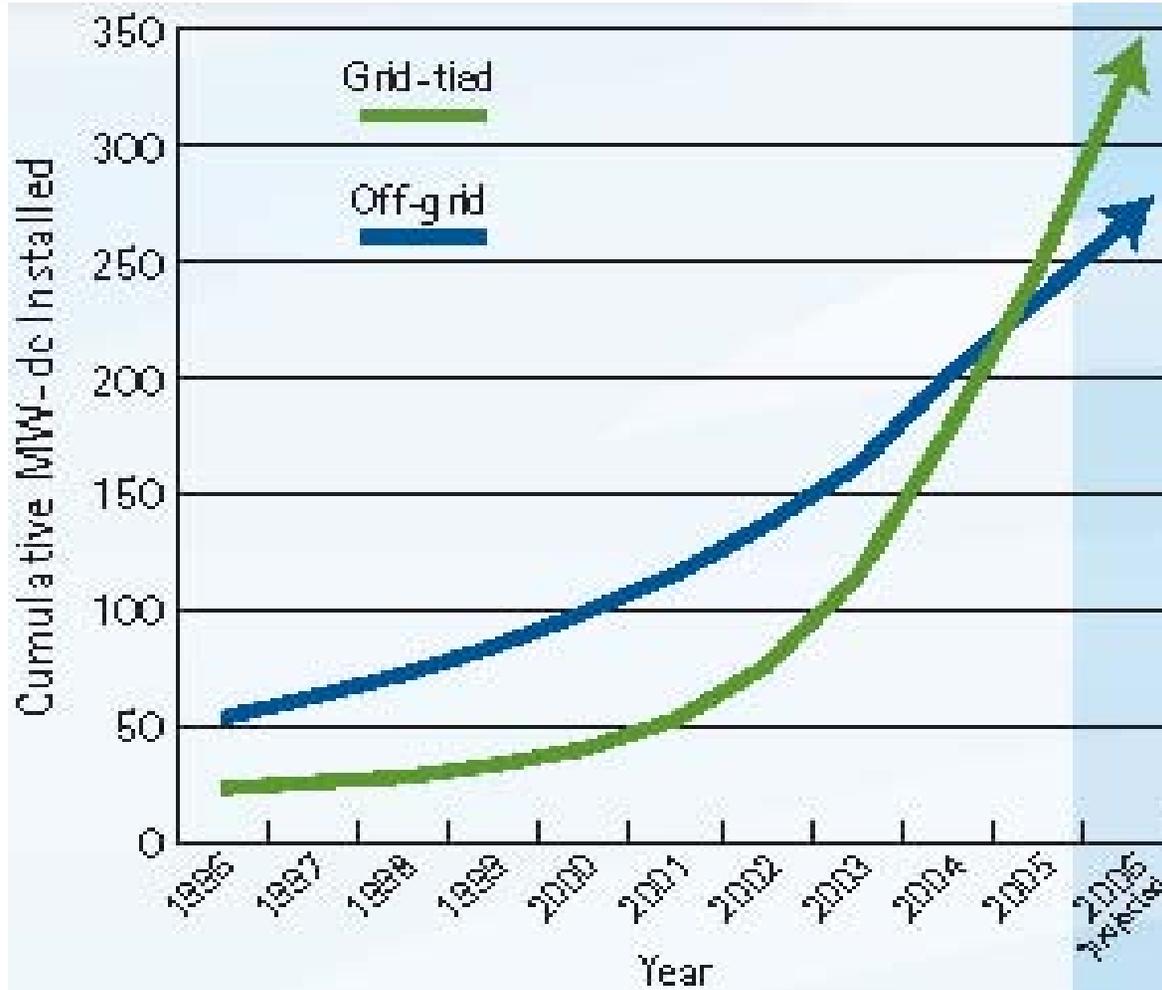




- **World-wide Production jumped 50% in 2007**
 - 3,800 megawatts (MW) increase worldwide in 2007
 - 12,400 MW cumulative worldwide production
 - **Enough energy to power 2.4 million U.S. homes**
- **U.S. Production has doubled every two years**
 - Average of 48% growth each year since 2002
 - World's fastest-growing energy resource
- **Polysilicon shortage began in 2004**
 - In 2006, more than half of polysilicon production went into PVs instead of computer chips
 - Supply is expected to match demand by 2010
- **Top 5 PV-producing countries are Japan, China, Germany, Taiwan and the U.S.**
 - China triples its PV production in 2006
 - Germany feed-in tariff of \$0.49 / kW-hour remains until 2009
 - Japan's phasing-out incentive program (250,000 homes with PV)



U.S. PV Installations





U.S. PV Installation Trends

- **U.S. installations increased from 20% to 33%**
 - Primarily driven by CA and NJ
- **CA Solar Initiative launched in January 2006**
 - Provide more than \$3 billion in solar power installation
 - Goal is to generate 3,000 MW of new solar by 2017
- **U.S. Energy Policy Act (EPAct) of 2005 PV incentives**
 - Up to \$2000 available to offset PV system costs
- **83% growth in installations in 2007**



Annual U.S. Grid-tied PV by Application





U.S. PV Commercial Installations

- **The majority commercial systems are in the grid-tied market**
 - a trend that has emerged only in the last few years.
- **Large commercial integrators such as Powerlight, Solar Integrated Technologies, New Vision, and the SunEdison are among many companies installing multi-hundred kW systems in California**
- **Unlike in Germany and Japan, the commercial market in the US is the predominant driver of PV deployment.**



U.S. PV Large-scale Installations

- **Nellis Air Force Base, NV**
14.2 MW
- **Alamosa, CO**
8 MW
- **Arizona Public Service - Prescott, AZ**
6 MW
- **Tucson Electric Power, AZ**
~ 4 MW
- **Orange County Center, CA**
2 MW
- **Santa Rita Jail, CA**
1.5 MW



The largest PV solar power plant in the U.S. is a reality at Nellis Air Force Base. Completed in December 2007.



Current PV Economics

Photovoltaic costs have steadily decreasing for the last five years

- Current module prices \$2.60-\$3.30/watt at the factory level
- Grid-connected system prices \$8.00-\$10.00/watt
- Levelized energy costs estimated at \$0.25 to \$0.35/kWhr



Latitude-tilt



Horizontal



Tracking



Concentrator



Sandia PV Program

Laboratory Research



PSEI



PVSOL



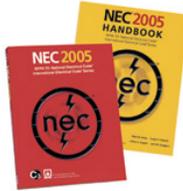
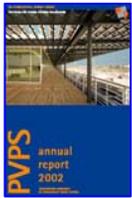
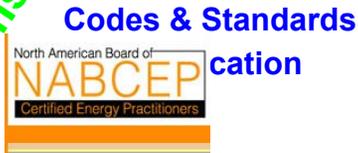
DETL

PV Center for Systems

- Engineering
- Manufacturing
- Analysis
- Evaluation
- Optimization

Industry

Leadership & Assistance



Performance & Analysis

