Solar Energy: Market Trends and Dynamics

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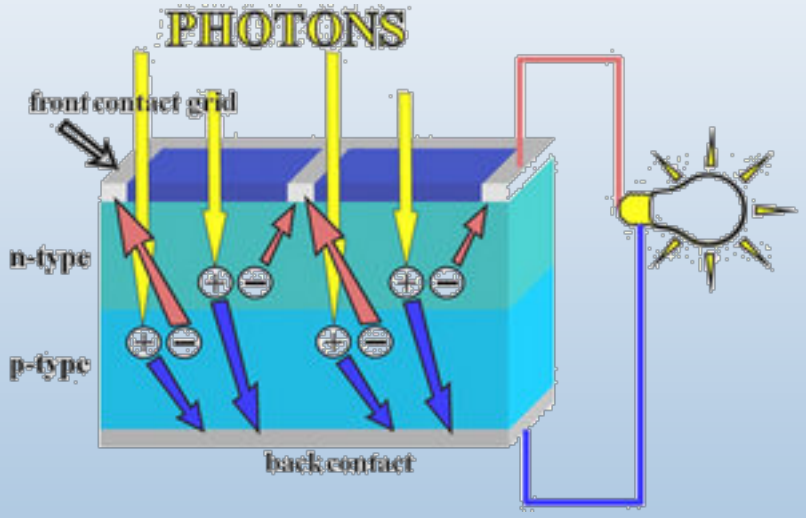
Agenda

- Overview of solar technologies
- Production and price trends
- Investment trends
- Moving towards grid-parity
- Factors driving continued growth

Converting the sun's radiation into electricity – two main pathways

Photovoltaics (PV)

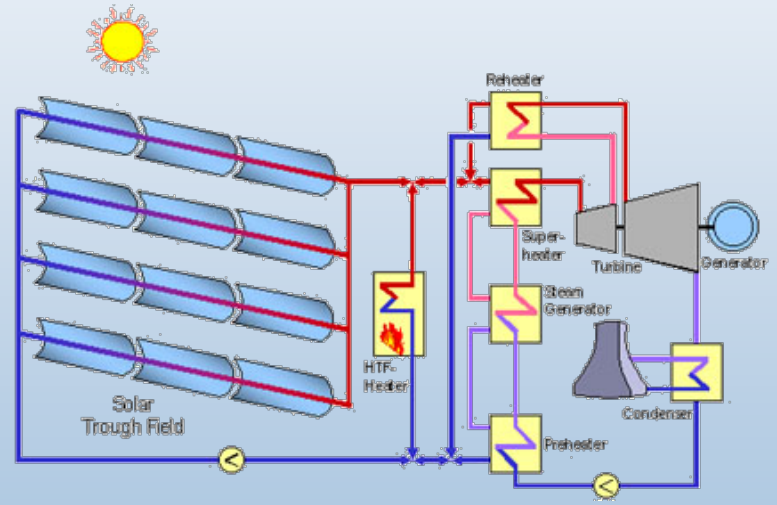
Cells of semi-conductors absorb photons and directly convert them into electrical current.



Can be used anywhere in the U.S.

Concentrating Solar Power (CSP)

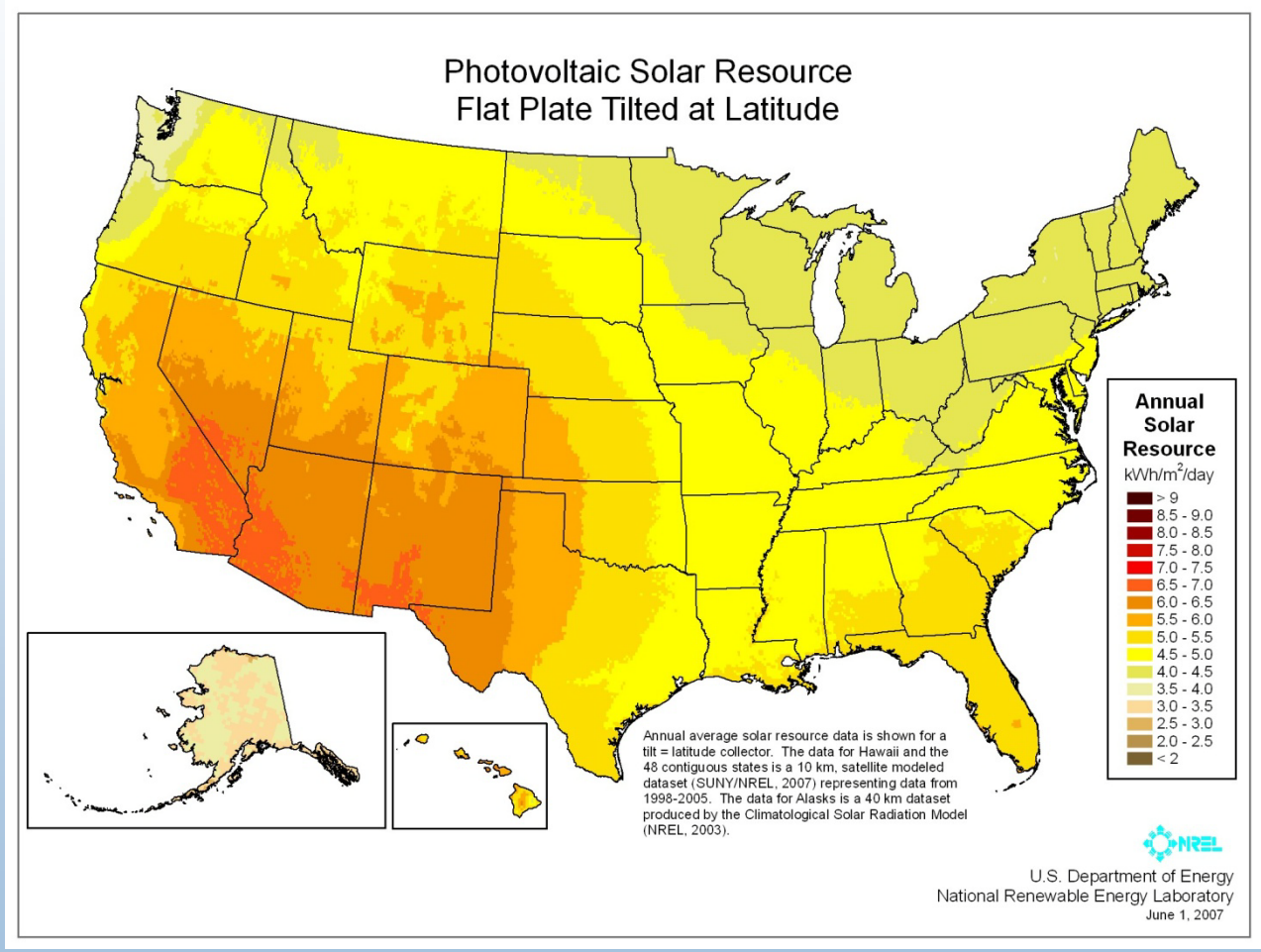
Mirrors focus solar radiation to heat fluids that are used to drive electric generators.



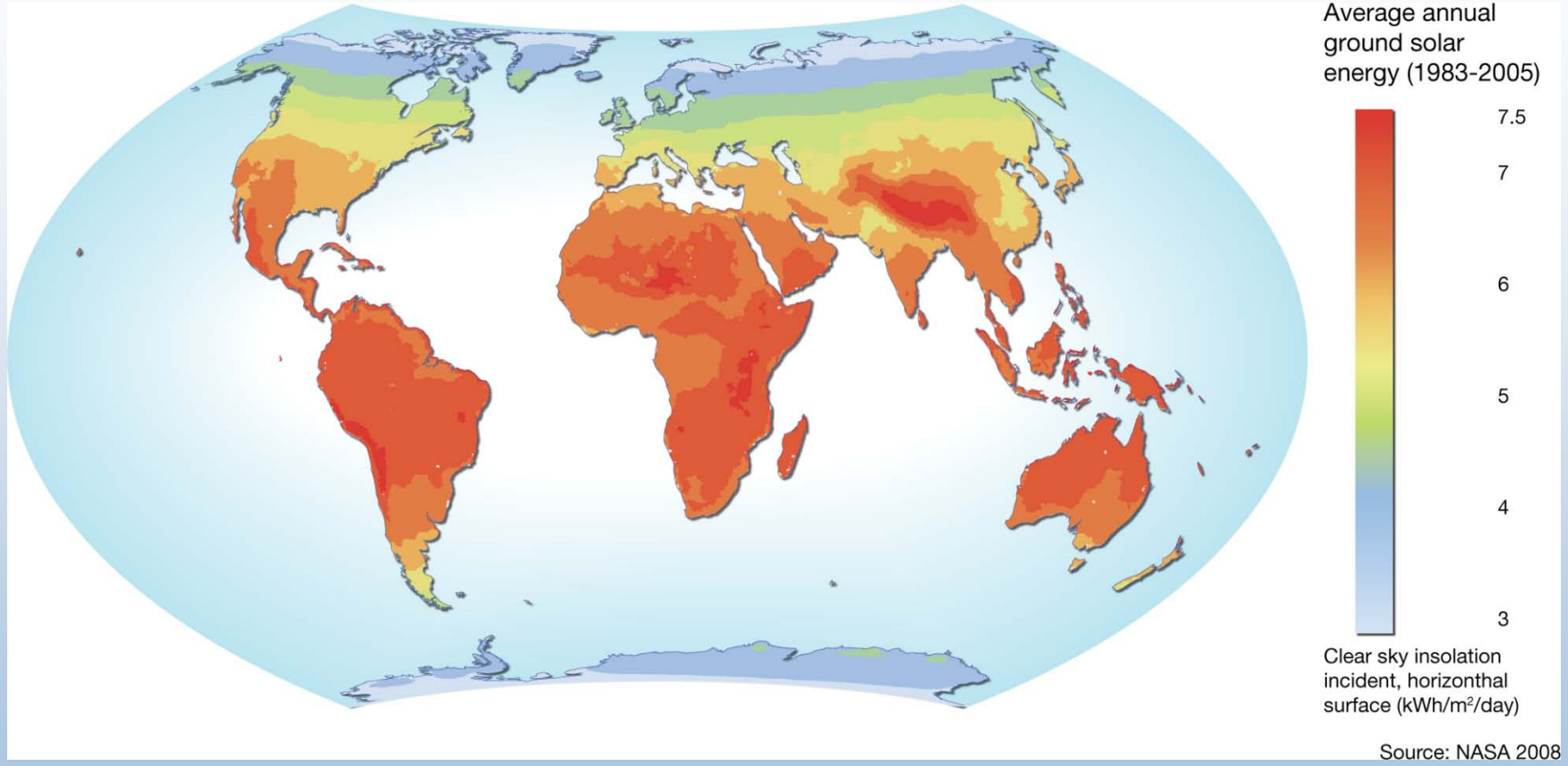
Predominantly in the Southwest U.S. (requires direct sunlight)

In the U.S. solar resources significantly outweigh energy use

- Currently, solar provides less than 0.1% of the electricity used in the U.S.
- For the U.S., less than 2% of the land dedicated to cropland and grazing could provide all of our electricity.

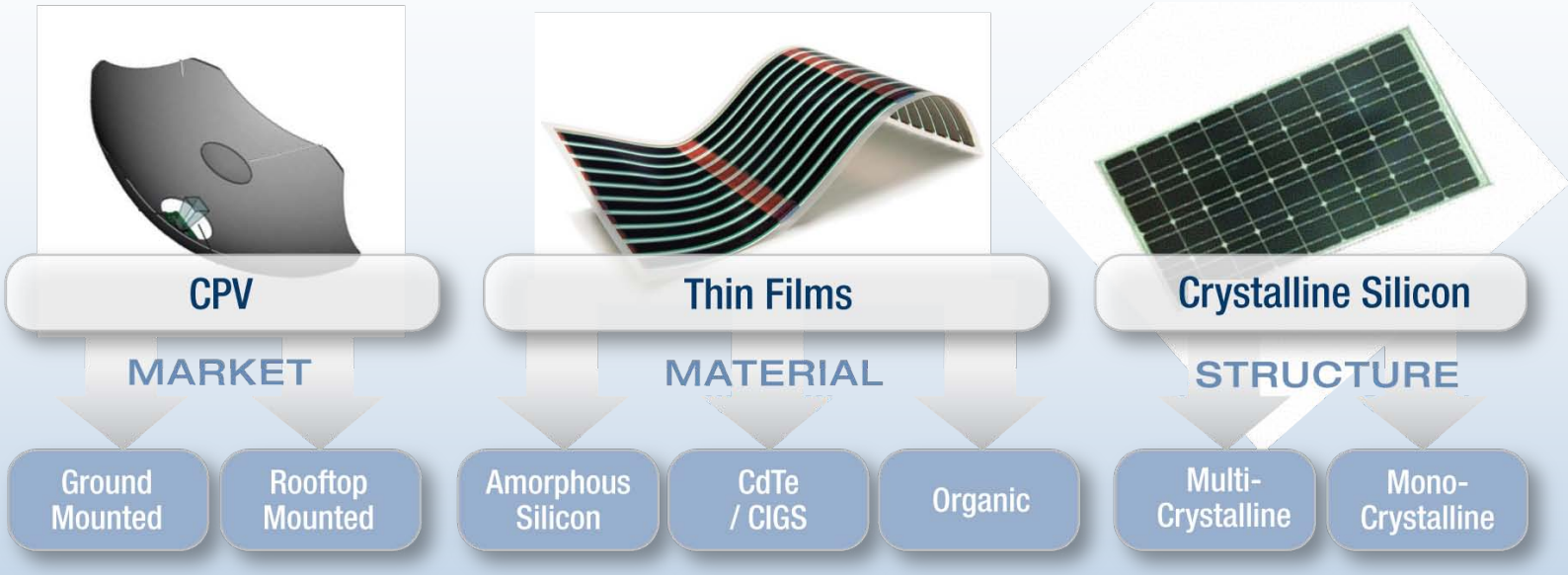


Also globally solar resources significantly outweigh energy use



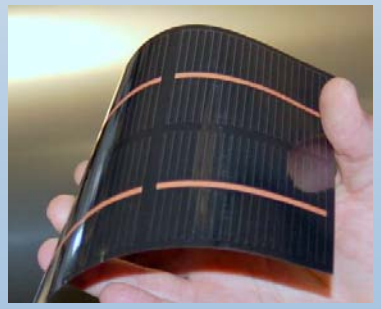
- Covering less than 0.2% of the land on the earth with 10%-efficient solar cells would provide twice the power used by the world.

Government and industry are pursuing a range of promising PV technologies…

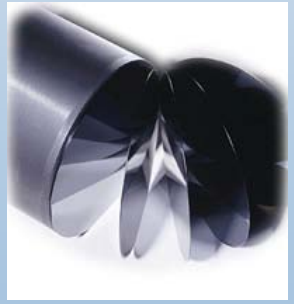


20x-100x

500x



Cu(In,Ga)Se_2 ~ 1-2 um



c-Si ~ 180 um

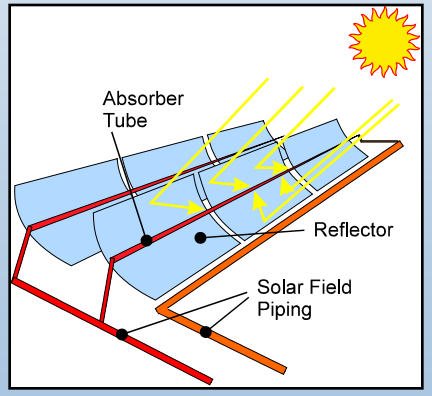
… and a range of promising Concentrating Solar Power (CSP) technologies

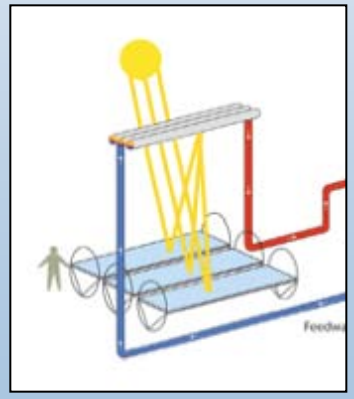
Trough

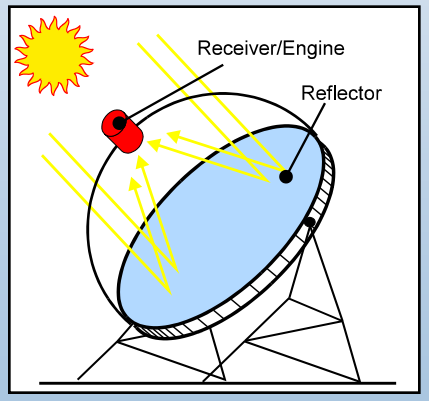
Linear Fresnel

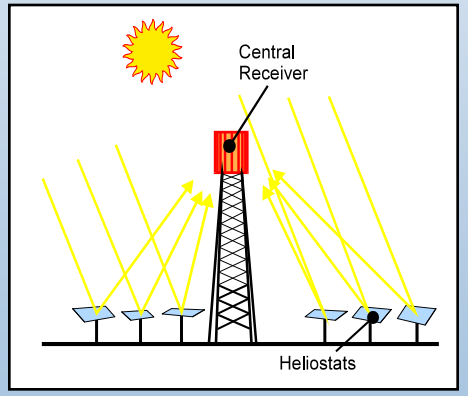
Dishes

Tower









Utility scale power plants – intermediate and base load power

Both PV and CSP applications and markets are evolving very rapidly

Residential

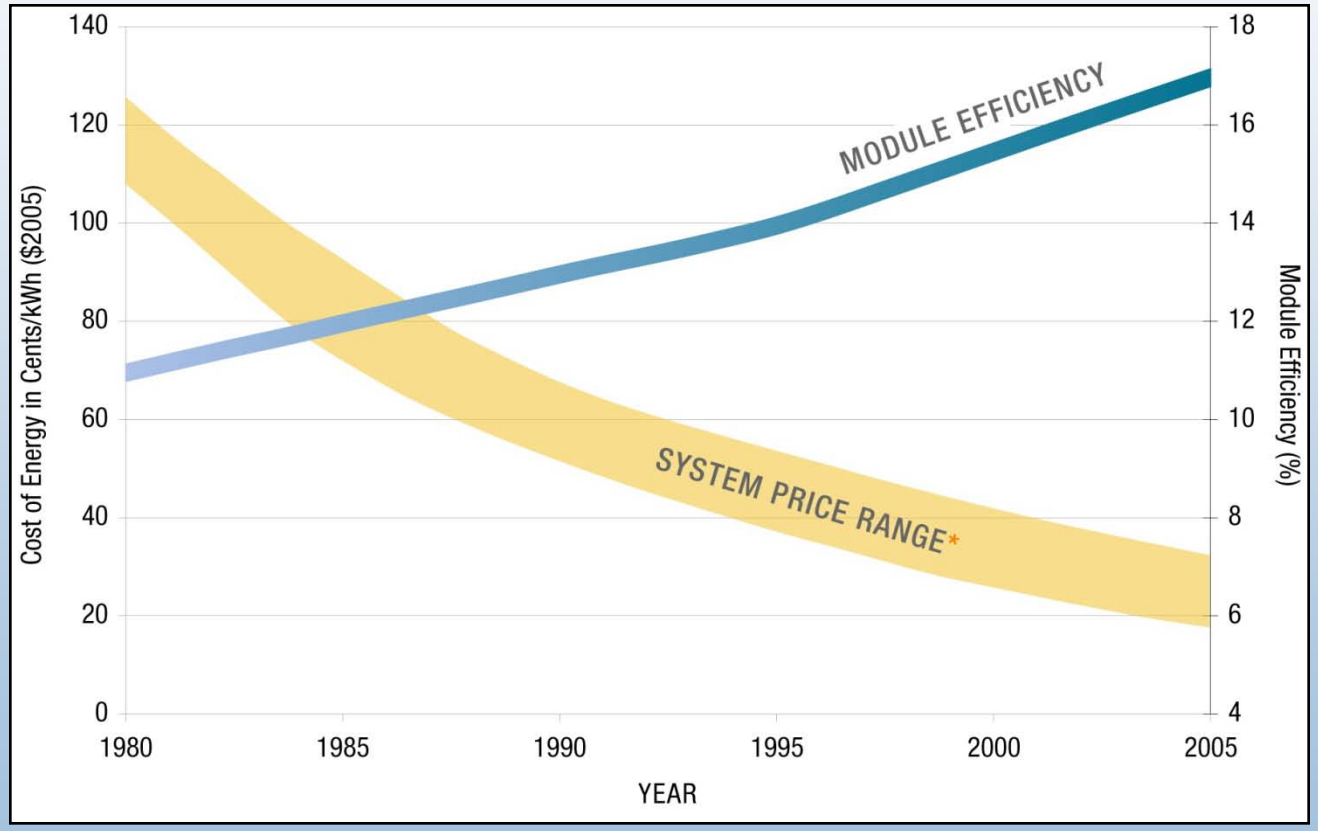
Commercial

Utility-scale

- Solar is a growing source for distributed & centralized electricity generation

Dramatic reduction in cost and increase in efficiency of PV over past 25 years

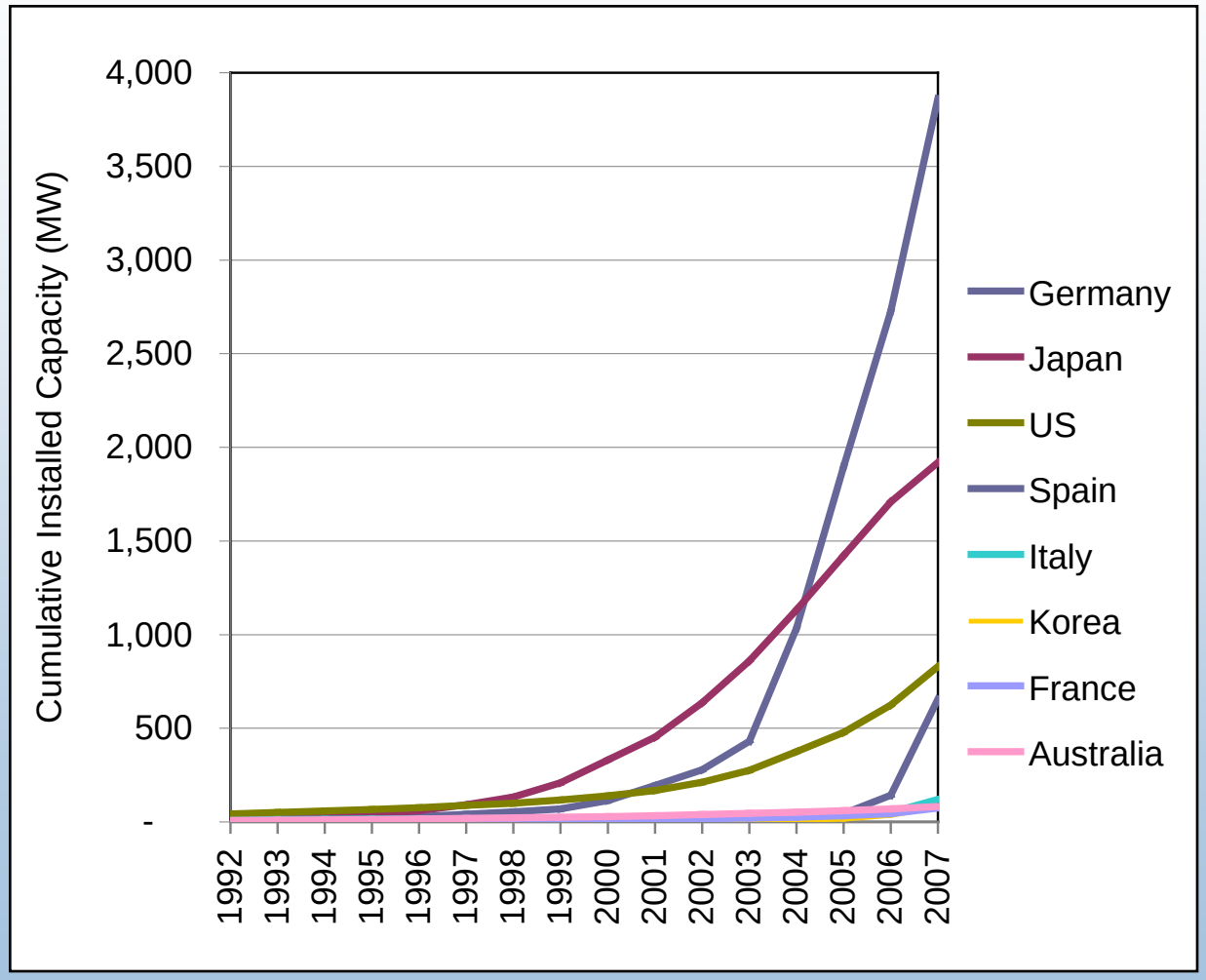
Historical PV Cost Curve (Silicon-based Technologies)



- Government investment in solar R&D has had a significant impact.
- System prices must come down another 50-70% to achieve grid-parity nationwide.

* System price is dependent upon location, application and variable financing options.
Source: NREL.

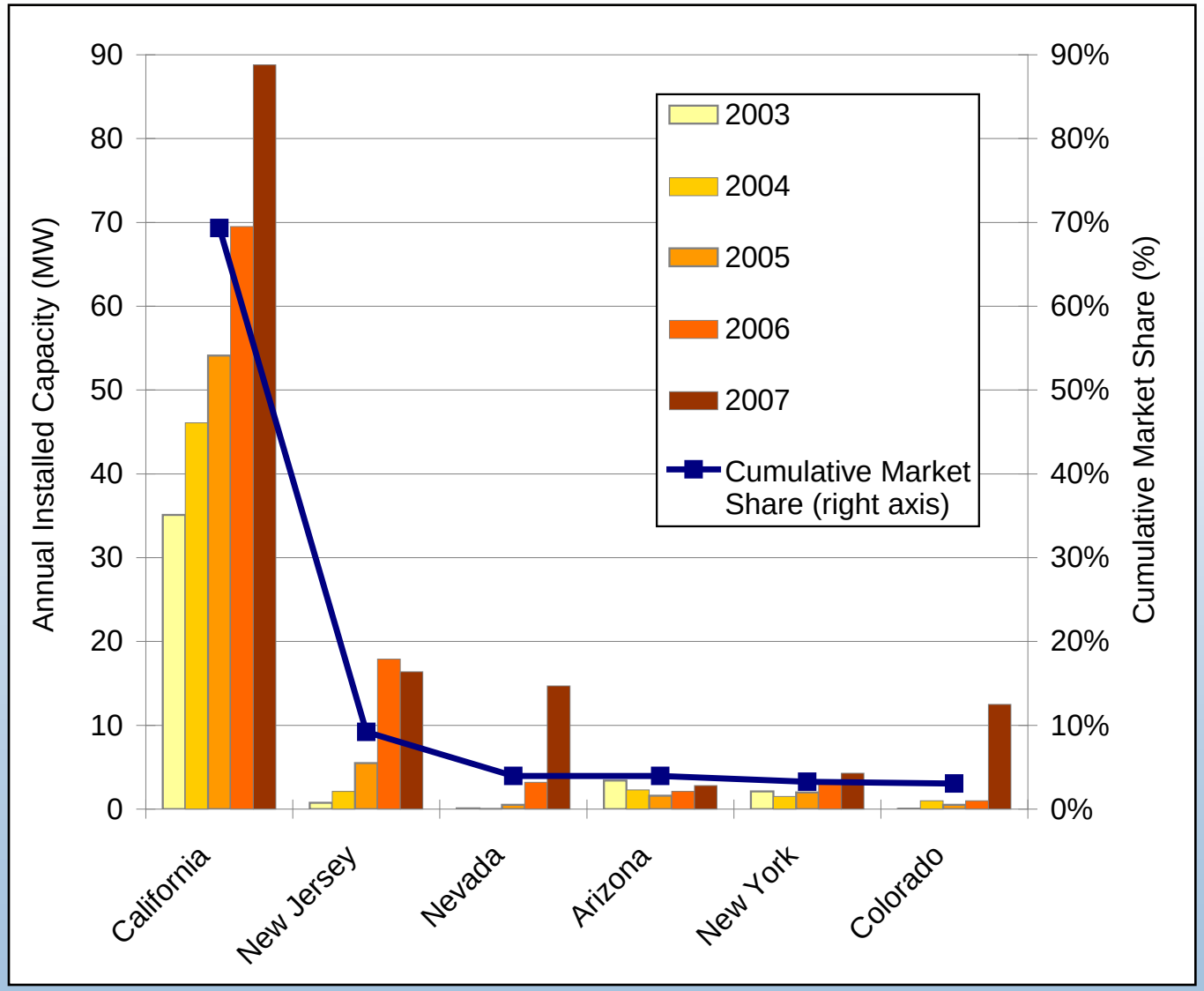
PV growing rapidly in key countries…



- Grid-connected PV is fastest growing market.
- Incentives have driven steep growth in installations.
- Average annual global growth rate has been 40+% for the past 5 years.
- Solar could capture > 30% of market share for new capacity additions during next 5-10 years.

Source: International Energy Agency (2008).

…and in a number of key states in the U.S.



- Top 6 states accounted for 92% of MW in 2007.
- Beginning to see installation of larger PV systems in 2007:
  - 14 MW at Nellis AFB, NV.
  - 8.4 MW at Alamosa, CO.
- Additional states to watch?
  - Florida,
  - Maryland,
  - Penn.,
  - Texas

Source: Larry Sherwood/IREC (2008).

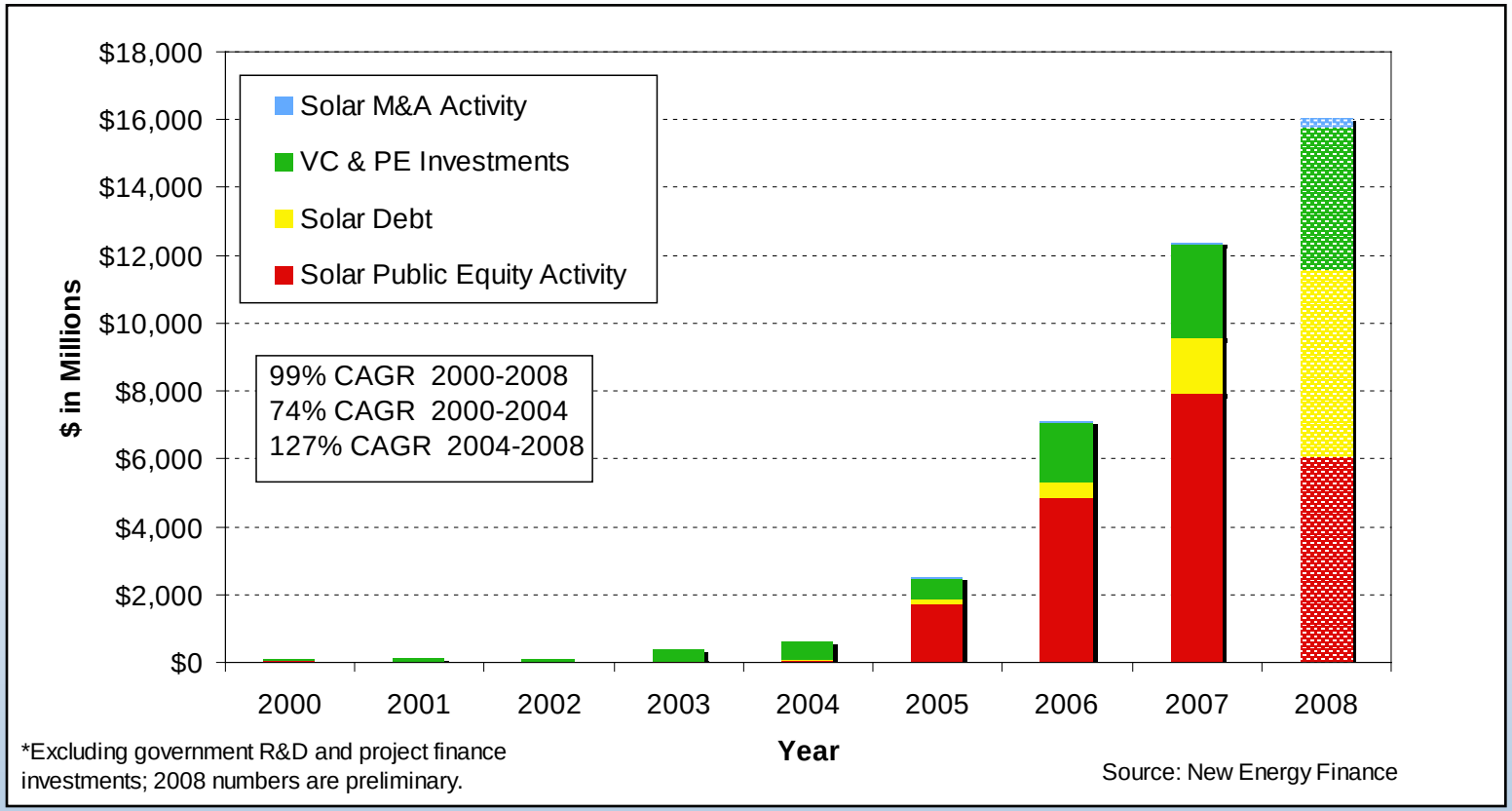
Have also seen a resurgence of interest and investment in CSP

CSP Installed Capacity

Plant name	Location	Technology Type	Year Installed	Capacity (MW)
Solar Electricity Generating Stations (SEGS)	California	Trough	1984-1991	354 total, comprised of nine, 14-80 MW plants
Saguaro	Arizona	Trough	2005	1
Nevada Solar One	Nevada	Trough	2007	64
PS10	Spain	Tower	2007	11
GEF Morocco ISCC Plant II	Morocco	Trough		6

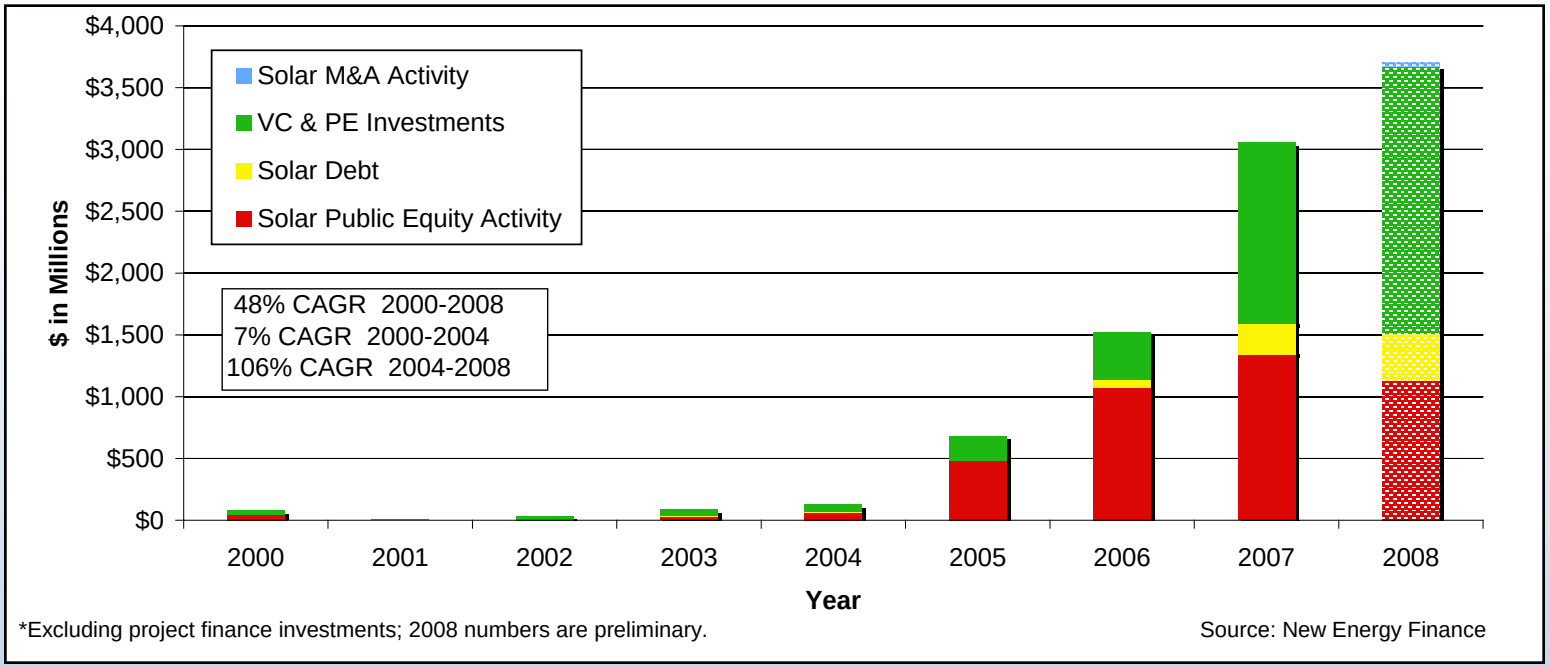
- Globally about **600 MW** of CSP is currently under construction (in Spain, North Africa, Mexico and China).
- An additional **9 GW** of CSP are in the pipeline, either announced or proposed through 2015 (43 % in US).

Total global investment in solar energy



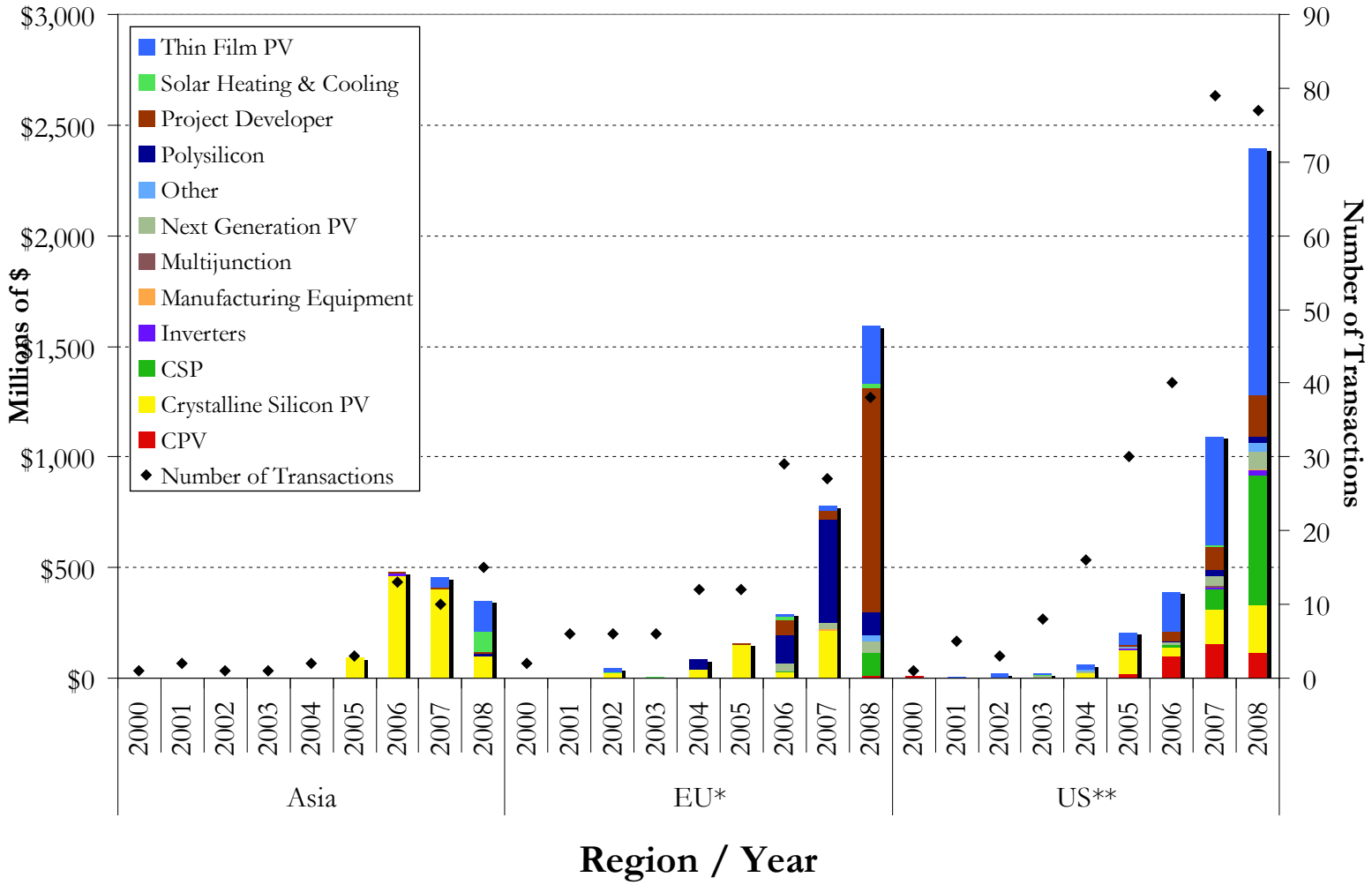
- Total global investment in solar increased from $66M in 2000 to over $16 billion in 2008.
- Venture Capital/Private Equity and Debt investments took on larger role in 2008.
- Most of 2008 investment (83%) took place during 1st three quarters of 2008 (Q4 accounted for only 17% of 2008 investment).

Total U.S. investment in solar energy

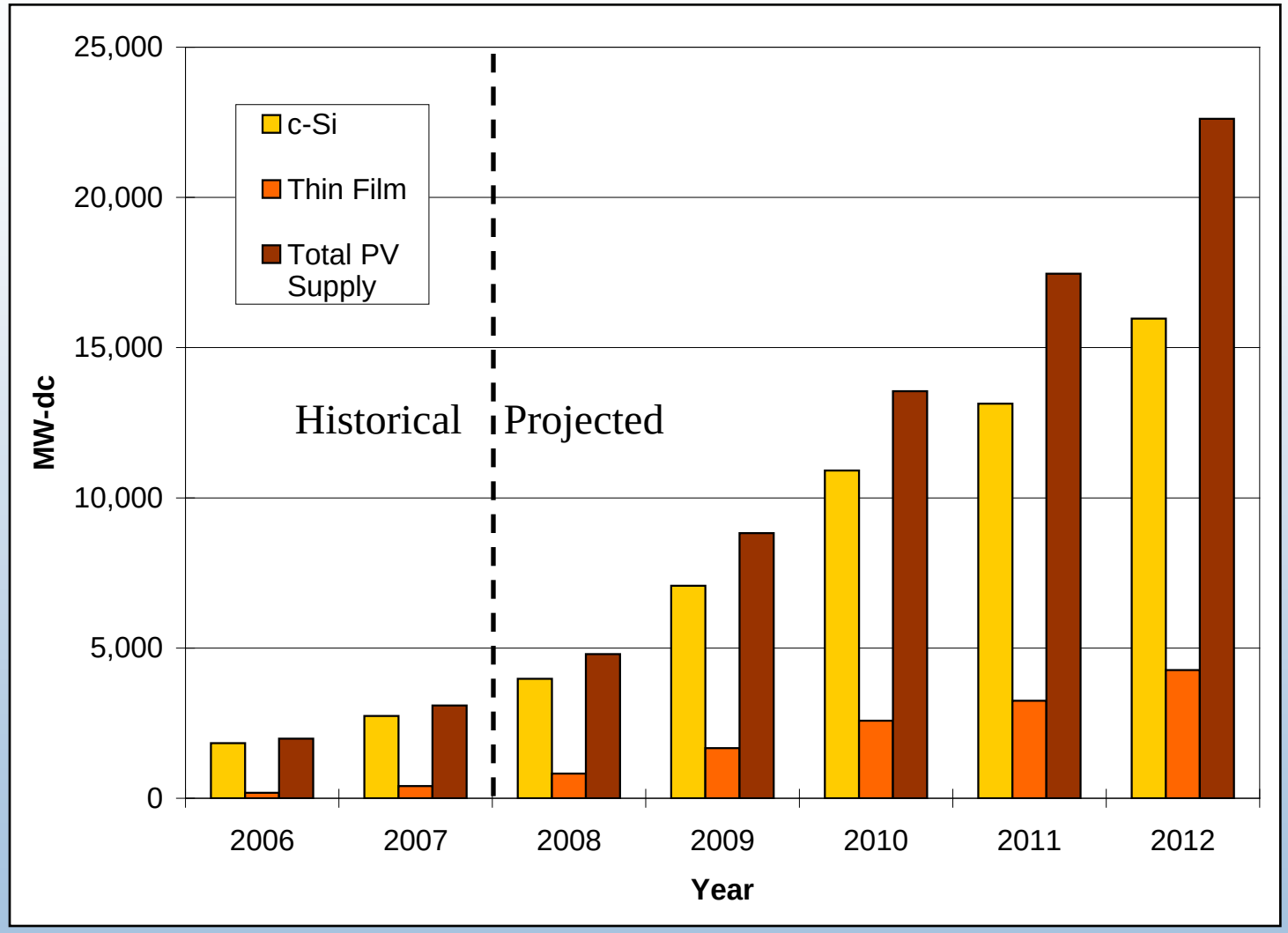


- Total U.S. investment in solar reached almost $4 billion in 2008 (~25% of global investment).
- In U.S. most of 2008 investment (87%) took place during 1st three quarters of 2008 (Q4 accounted for only 13% of 2008 investment).
- U.S. investors have been pursuing a more diverse set of technologies than investors in other regions (including thin-film PV, next generation PV, concentrating PV, and CSP).

Regional investment in solar technology



PV production is projected to grow ~ 5x over the next couple of years



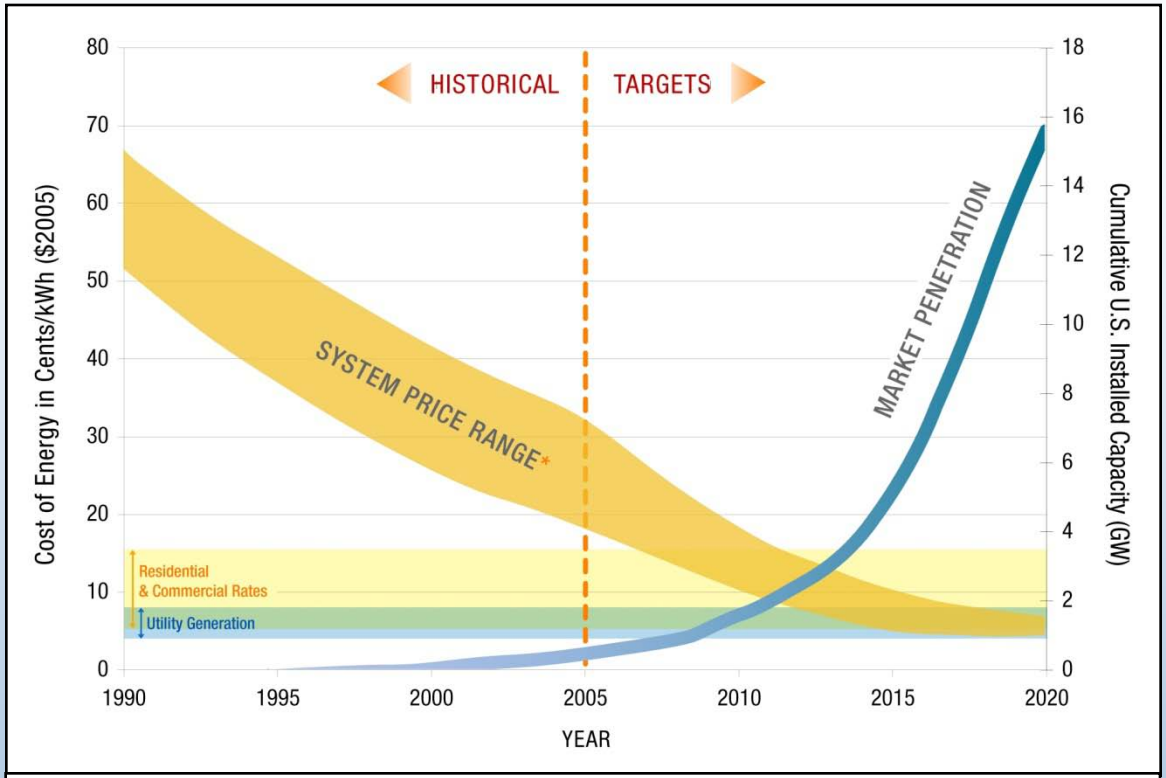
- c-Si is expected to remain dominant.
- But, thin-film is expected to grow more rapidly.
- Financial crisis has led some analysts to lower their projections (10-25%).

Source: Median values from projections by 11 industry analysts (Nov 2007 – Jan 2009).

PV is expected to reach grid parity in U.S. between 2010 and 2015

But many challenges:

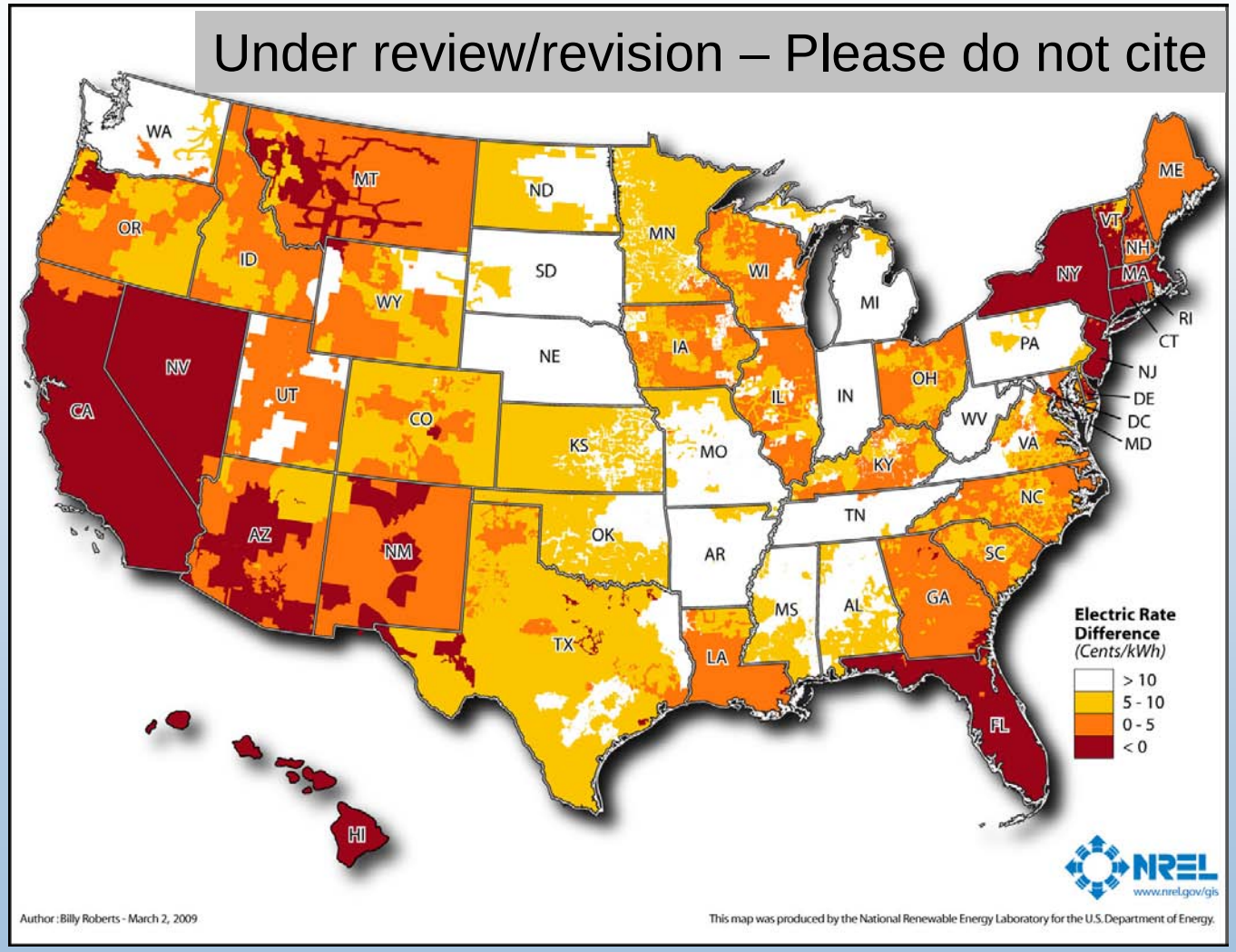
- Reducing cost
- Improving performance and reliability
- Maintaining balance between supply and demand (polysilicon supply, manufacturing capacity, distribution/ installation networks)
- Understanding and acceptance by financial sector, regulators, utilities
- Integrating solar with other systems (grid, buildings)



Market Sector	Current U.S. Market Price Range (¢/kWh)	Cost (¢/kWh) Benchmark 2005	Cost (¢/kWh) Target 2010	Cost (¢/kWh) Target 2015
Residential	5.8-16.7	23-32	13-18	8-10
Commercial	5.4-15.0	16-22	9-12	6-8
Utility	4.0-7.6	13-22	10-15	5-7

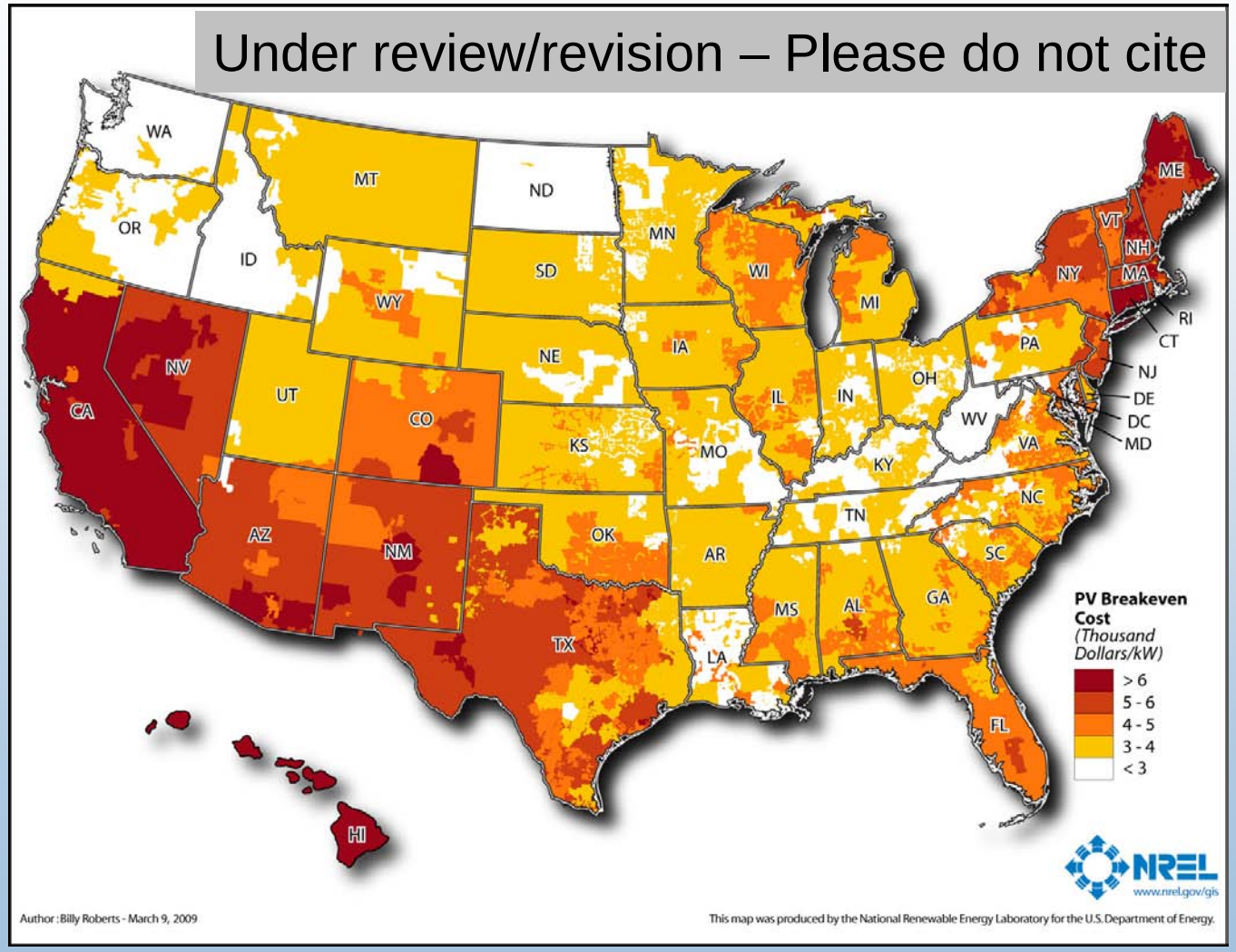
2009 residential PV and electricity price differences with existing incentives

- Analysis for 1000 largest utilities in the U.S.
- Key drivers for PV are incentives, electricity prices and quality of the solar resource.



2015 residential breakeven cost with federal ITC but no state incentives

- At $5/W, attractive in 98 of 1,000 largest utilities, which provide ~25% of U.S. residential electricity sales.
- At $4/W attractive in 328 utilities, ~42% of sales.
- At $3/W attractive in 743 utilities, ~80% of sales.



A number of factors are driving strong growth in the solar industry

- Federal, state, and local policy incentives.
- Market volatility, especially with respect to natural gas and oil.
- Climate change and likely carbon regulations.
- Energy security issues.
- Need for increased energy production to meet growing demand (China, India, etc.).
- Interest from financial community in “next big thing”.