
Solar Energy Industry Forecast: Perspectives on U.S. Solar Market Trajectory

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United States Department of Energy
Solar Energy Technologies Program



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Agenda



- Energy markets / forecasts
- DOE Solar America Initiative overview
- Capital market investments in solar
- Solar photovoltaic (PV) sector overview
 - PV prices and costs
 - PV market evolution
- Market evolution considerations
 - Balance of system costs
 - Silicon 'normalization'
 - Solar system value drivers
- Solar market forecast
- Additional resources

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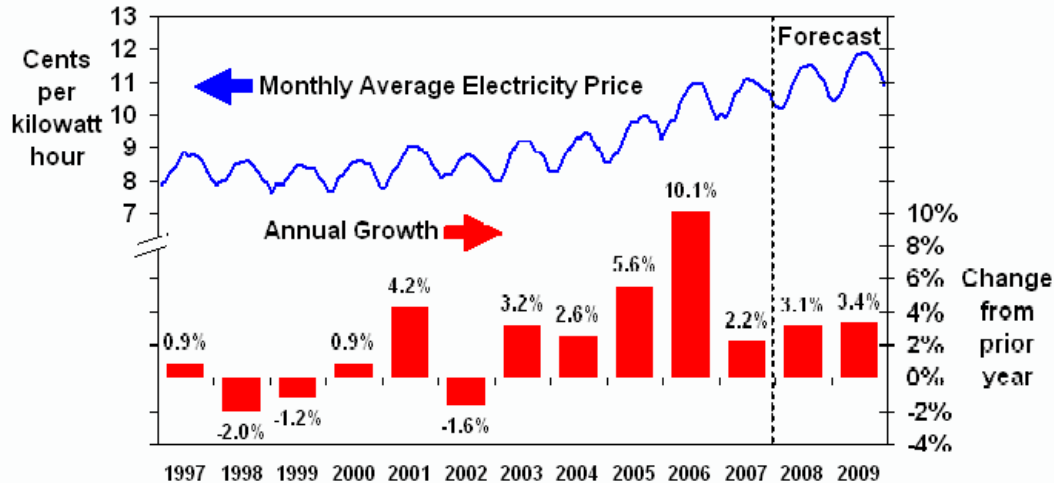


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Today's U.S. Electricity Cost Landscape



U.S. Residential Electricity Price



- Conservative forecasts from the Energy Information Agency (EIA) show residential electricity prices reaching 12 c/kWh by 2009

Short-Term Energy Outlook, May 2008



- EIA shows historic national average retail electricity prices outpacing inflation by ~1.2%

EIA National Retail Electricity (cents / kwh)

2007	10.64
2006	10.40
2005	9.45
2004	8.95
2003	8.72
2002	8.44

+ 4.7% per annum

EIA forecasts are good baselines, but are generally conservative as they are based on historical data without recent movement in supply/demand balances

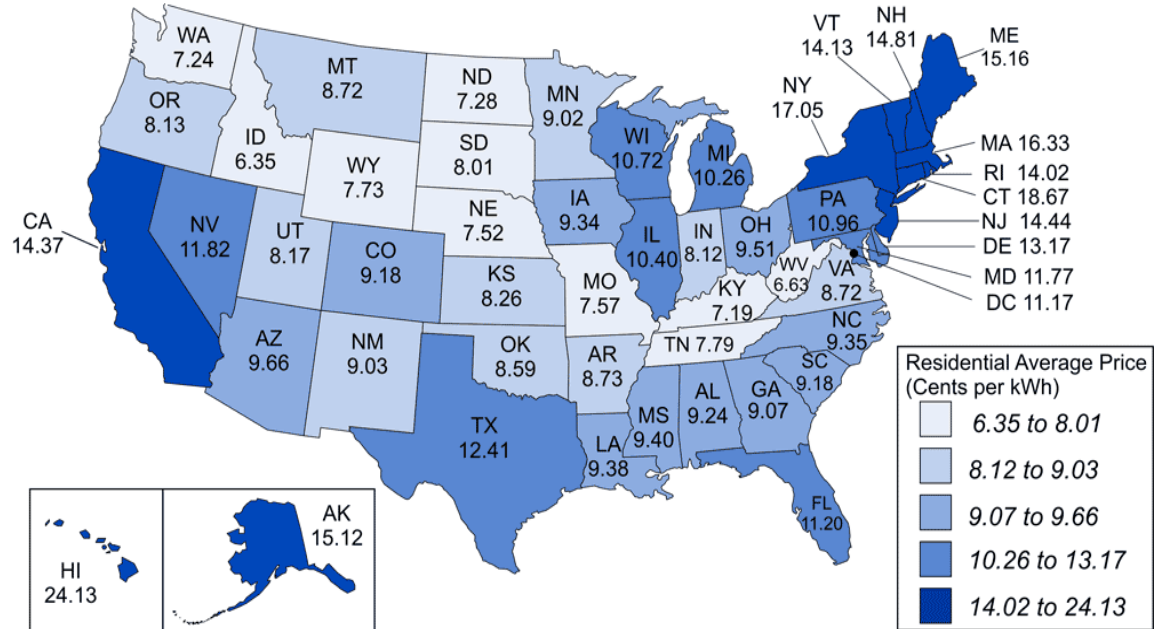
U.S. National Electricity Price Forecast



- Applying the same conservative 4.7% inflationary rate, average US electricity prices will reach 16 c/kWh by 2015
- Rates in some states will be higher, with CT electricity prices forecast to reach 27 c/kWh in 2015 by the same logic

Year*	c/kWh
2008E	11.55
2009E	12.09
2010E	12.66
2011E	13.26
2012E	13.88
2013E	14.53
2014E	15.21
2015E	15.93

The U.S. average residential retail price of electricity was 10.64 cents per kilowatthour in 2007.



*Estimates

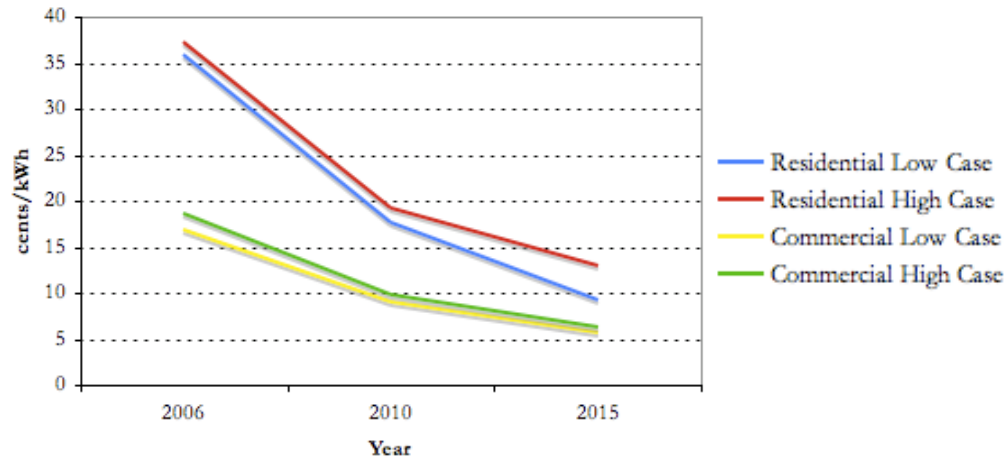
Source: Energy Information Administration, Form EIA-826, "Monthly Electric Sales and Revenue with State Distributions Report."

Solar is already cost competitive in some states today and will be in many more in coming years as energy prices increase nationwide

Installed system cost ranges have implications for levelized cost of energy

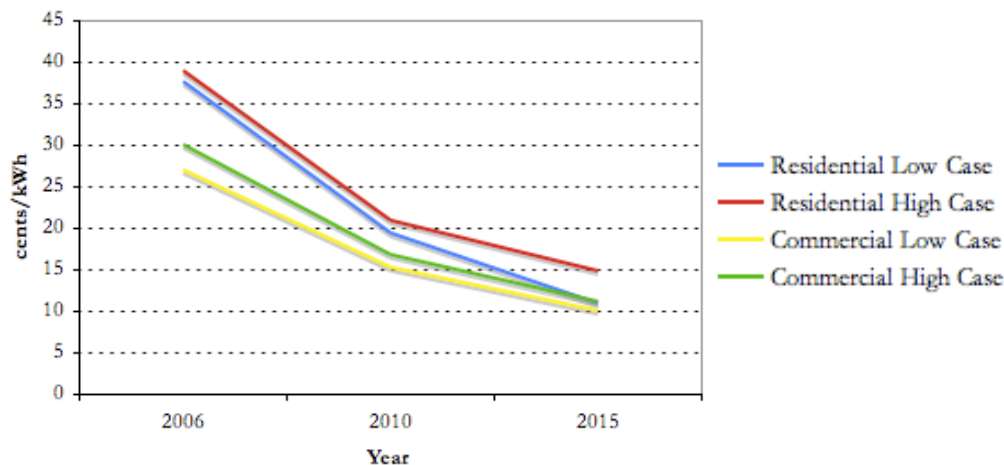


Levelized Energy Cost with Current Federal Incentives



- Commercial / utility scale PV systems are currently economically competitive with grid electricity prices in many areas

Levelized Energy Cost with NO Incentives



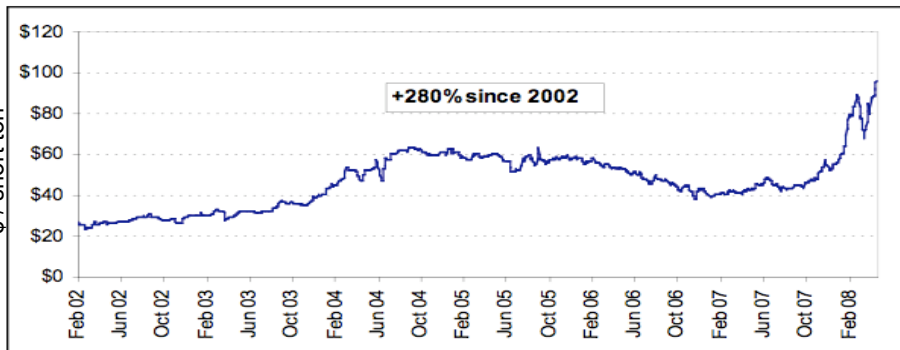
- Both residential and commercial systems will be less expensive than grid electricity by 2010, assuming that the 4.7% annual growth rate continues

Solar market penetration is created by the levelized cost of energy (LCOE) over the lifetime of the solar system vs. grid electricity prices and government/utility incentives

Traditional generation sources face hurdles even as demand grows



CAPP Front Month Contract Pricing (\$/ton)

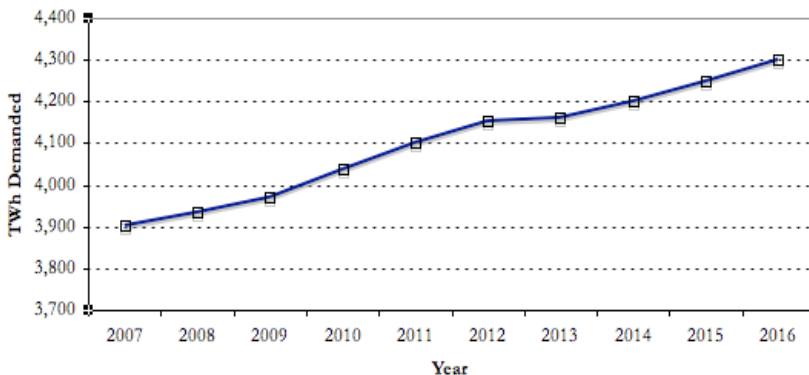


Source: Bloomberg.

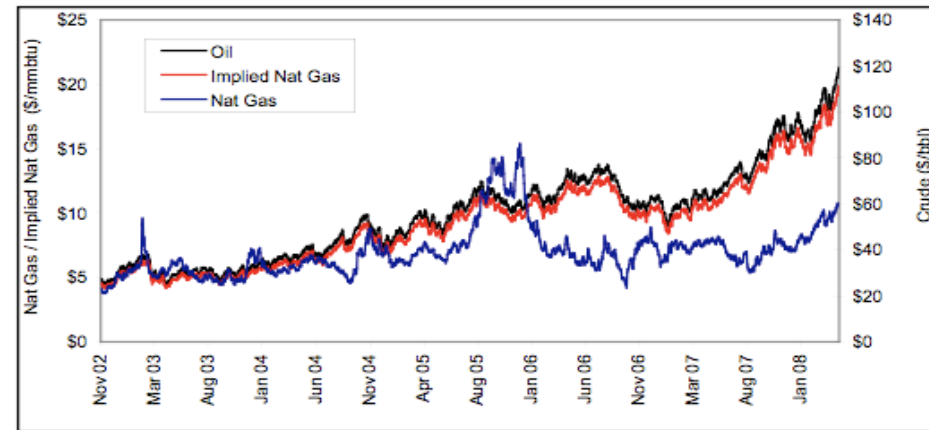
- Coal prices have nearly tripled over the past five years
- Coal power plants face increasing project uncertainty due to carbon and siting concerns

- Natural gas prices have more than doubled during the same time period

U.S. Electricity Demand Forecast



Source: EIA AEO 2008



Source: Bloomberg.

Source: Simmons & Co.

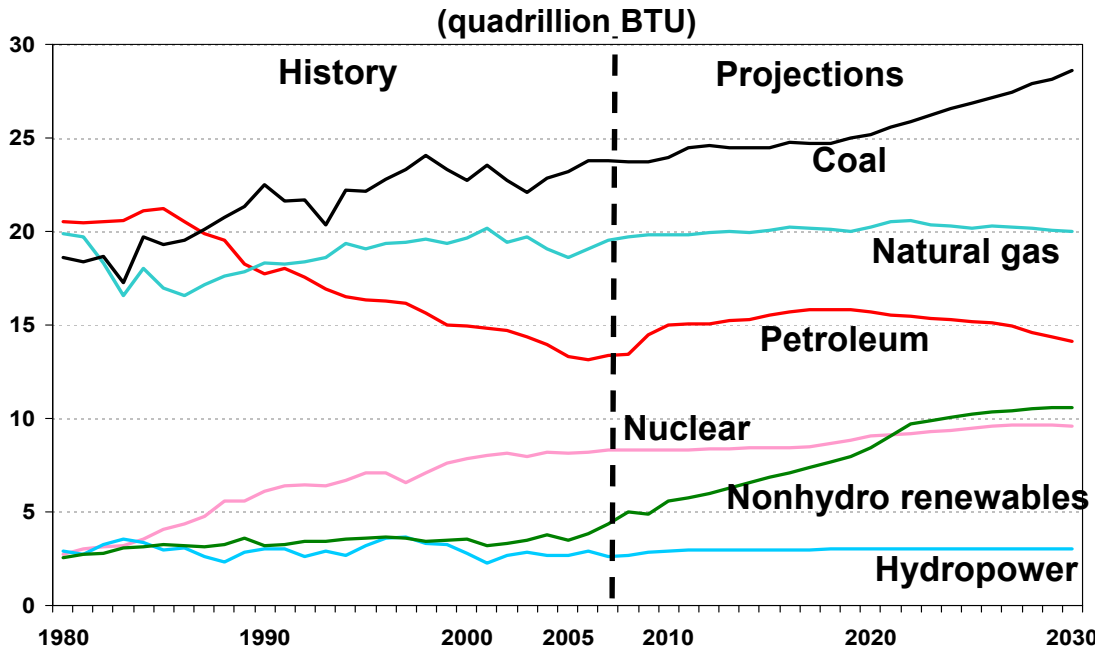
- Nuclear industry groups estimate the next generation nuclear plants will not be online until 2015
- Electricity demand is forecast to increase by **386 TWh** through 2015, requiring substantial capacity additions

Coal and natural gas prices are increasing at much faster rates than 4.7% per year, while nuclear faces regulatory, financing and siting issues.

Most forecasts do not take into account these hurdles



Energy Generation by Fuel, 1980-2030

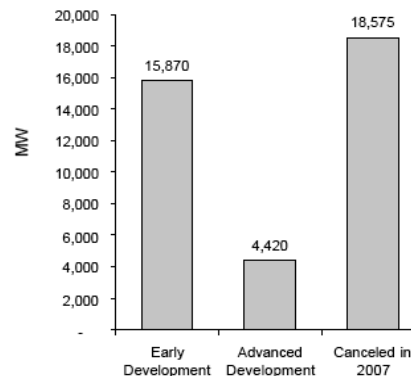


Source: EIA, Annual Energy Outlook 2008

- EIA recognizes that no nuclear will enter the generation mix in the next five years
- However, EIA forecasts include substantial coal and natural gas generation capacity additions.

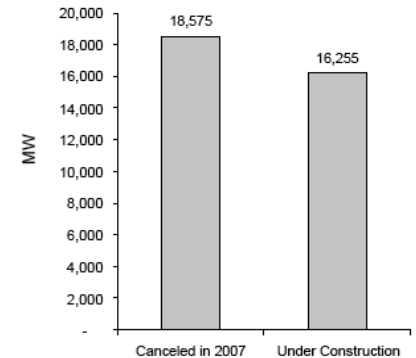
- Coal additions are difficult in today's regulatory and consumer market.
- Coal plants are being cancelled and CCS technology is being delayed
- Additional coal generation faces financing uncertainty due to the political risk of mandatory carbon values.

Coal Plants Canceled vs. Those in Development



Source: Platts PowerDat and Bernstein analysis

Coal Plants Canceled vs. Those in Construction



Source: Platts PowerDat and Bernstein analysis

The political climate is pushing in the same direction as electricity market economics



“**Energy security** and **climate change** are two of the great challenges of our time.”

- President Bush,
Major Economies Meeting, September 2007



“...proposals that will allow America to lead the world in combating global **climate change** ... to help develop and deploy the next generation of **energy** that will allow us to build the next generation’s economy.”

- Senator Barack Obama,
Portsmouth, NH, October 2007

“...the fundamental incentives of the market are still on the side of **carbon based energy**. This has to change...”

- Senator John McCain,
Arlington, VA, May 2008



“...move us from a **carbon based** economy to an efficient, green economy by unleashing a wave of private-sector innovation in **clean energy**...”

- Senator Hillary Rodham Clinton,
Cedar Rapids, IA November 2007

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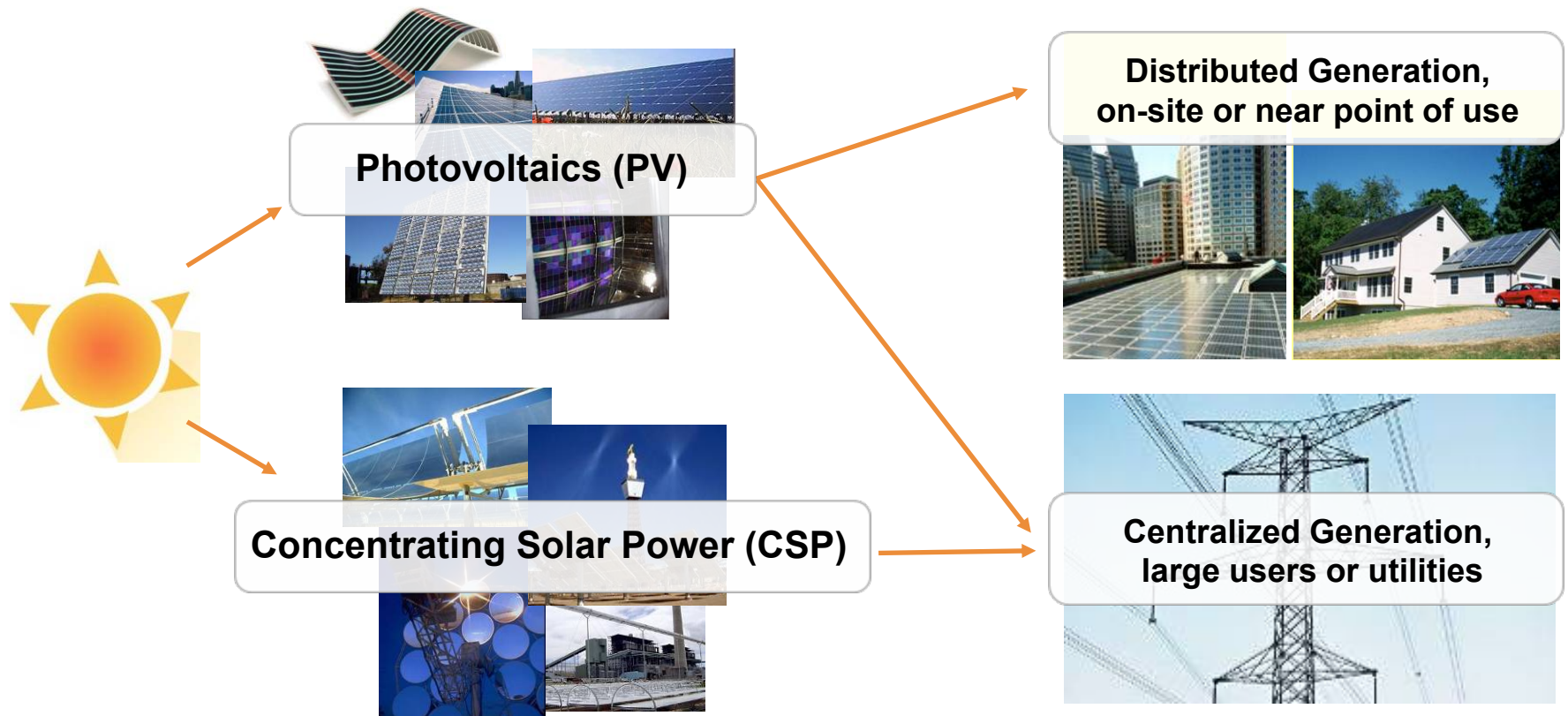
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The President's Solar America Initiative (SAI) drives Federal work.



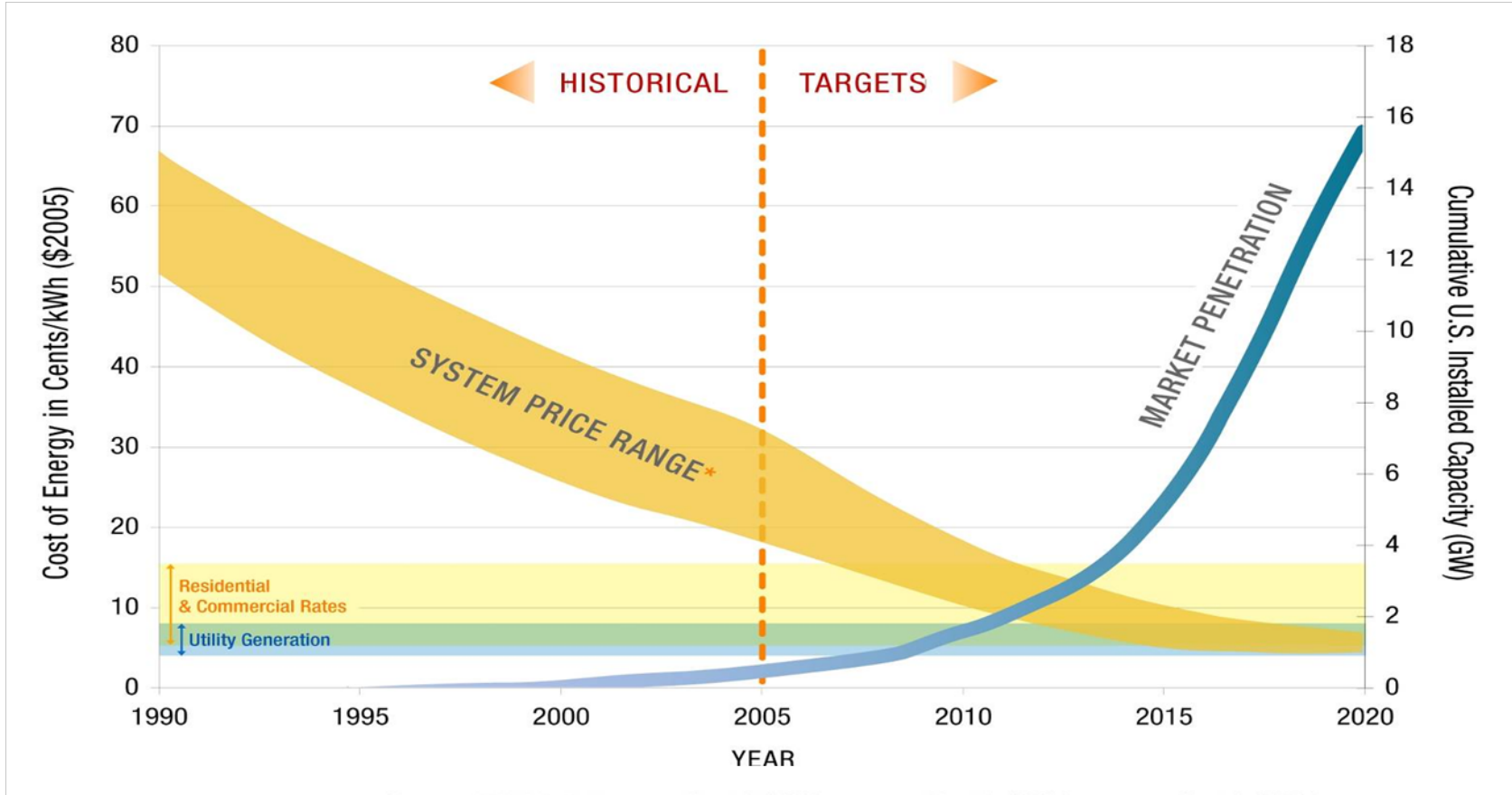
Achieve grid parity for solar electricity from photovoltaics across all market sectors by 2015.

In the next years of the SAI, the DOE's Solar Program will focus on achieving price-parity and scale for solar electricity generation from *both PV and CSP*



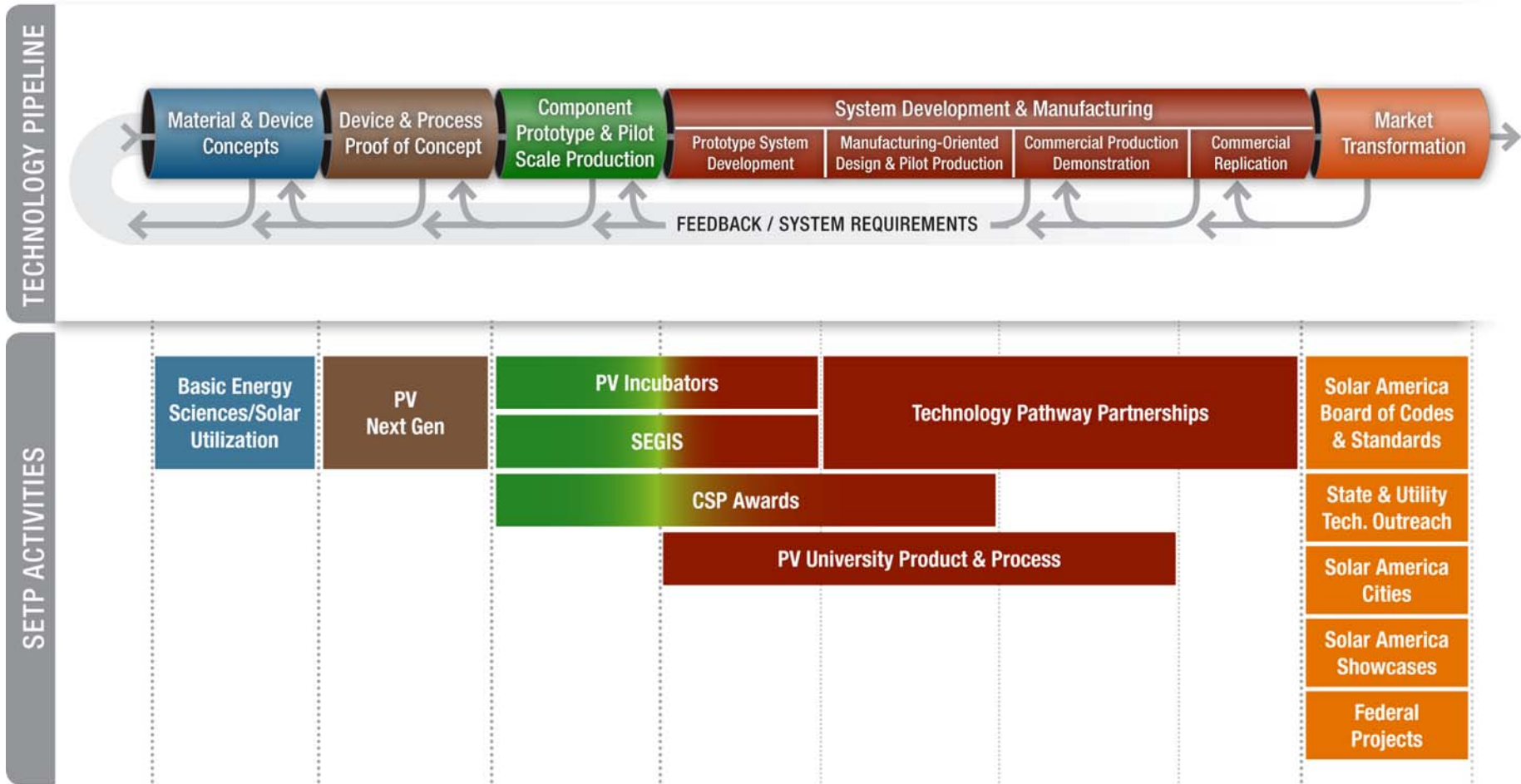
PV program will target >30% market share for annual new capacity additions, CSP program will target baseload price/dispatchability and GW-scale.

Genesis of the initiative:



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

SAI works along the whole RDD&D pipeline



SAI has many strong partnerships.



Massachusetts
Institute of
Technology



City of
Pittsburgh



Smithsonian
Institution



BLUE SQUARE
ENERGY



CH2MHILL



SUNPOWER



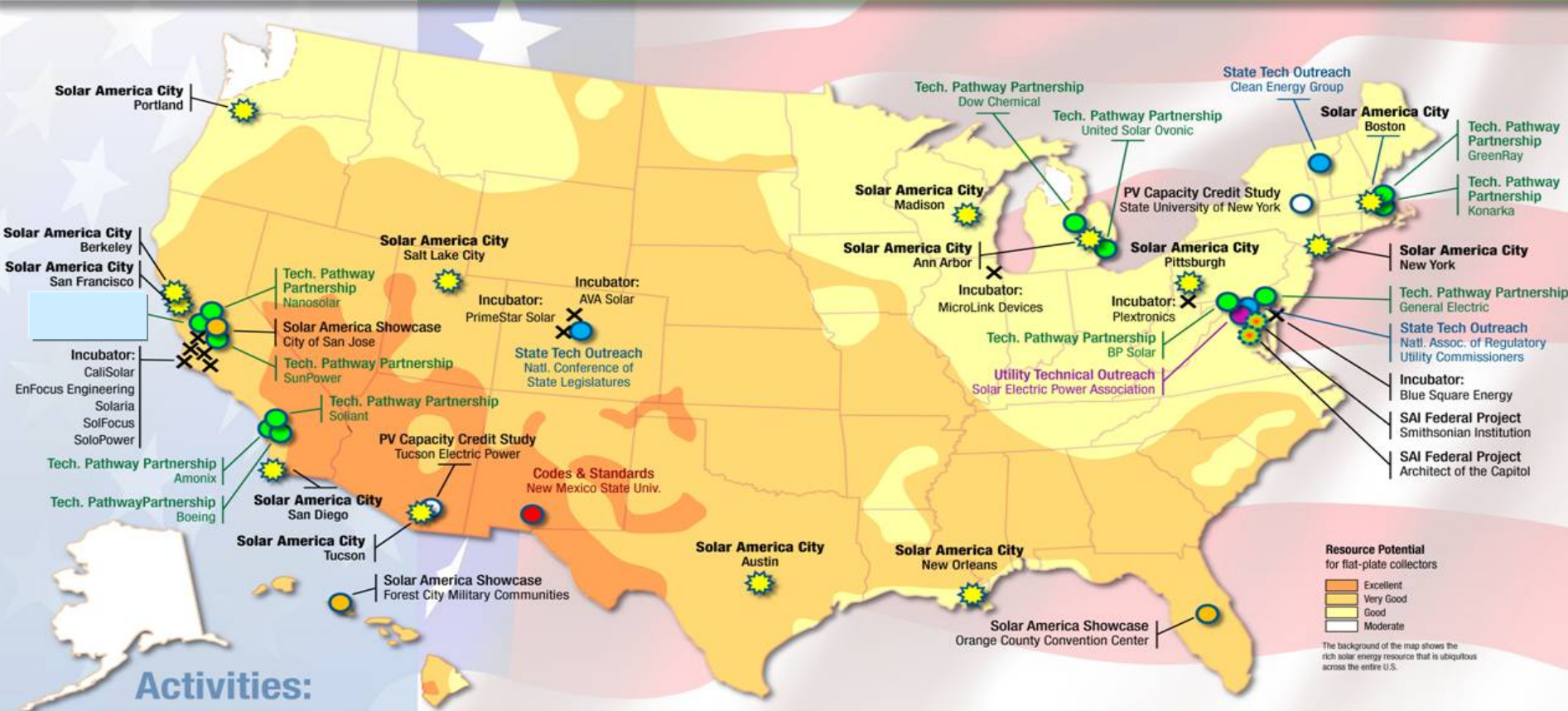
CITY OF NEW ORLEANS



SOLARIA



Solar America Initiative Across America



Resource Potential for flat-plate collectors

- Excellent
- Very Good
- Good
- Moderate

The background of the map shows the rich solar energy resource that is ubiquitous across the entire U.S.

Activities:

Transforming Markets and Creating Demand

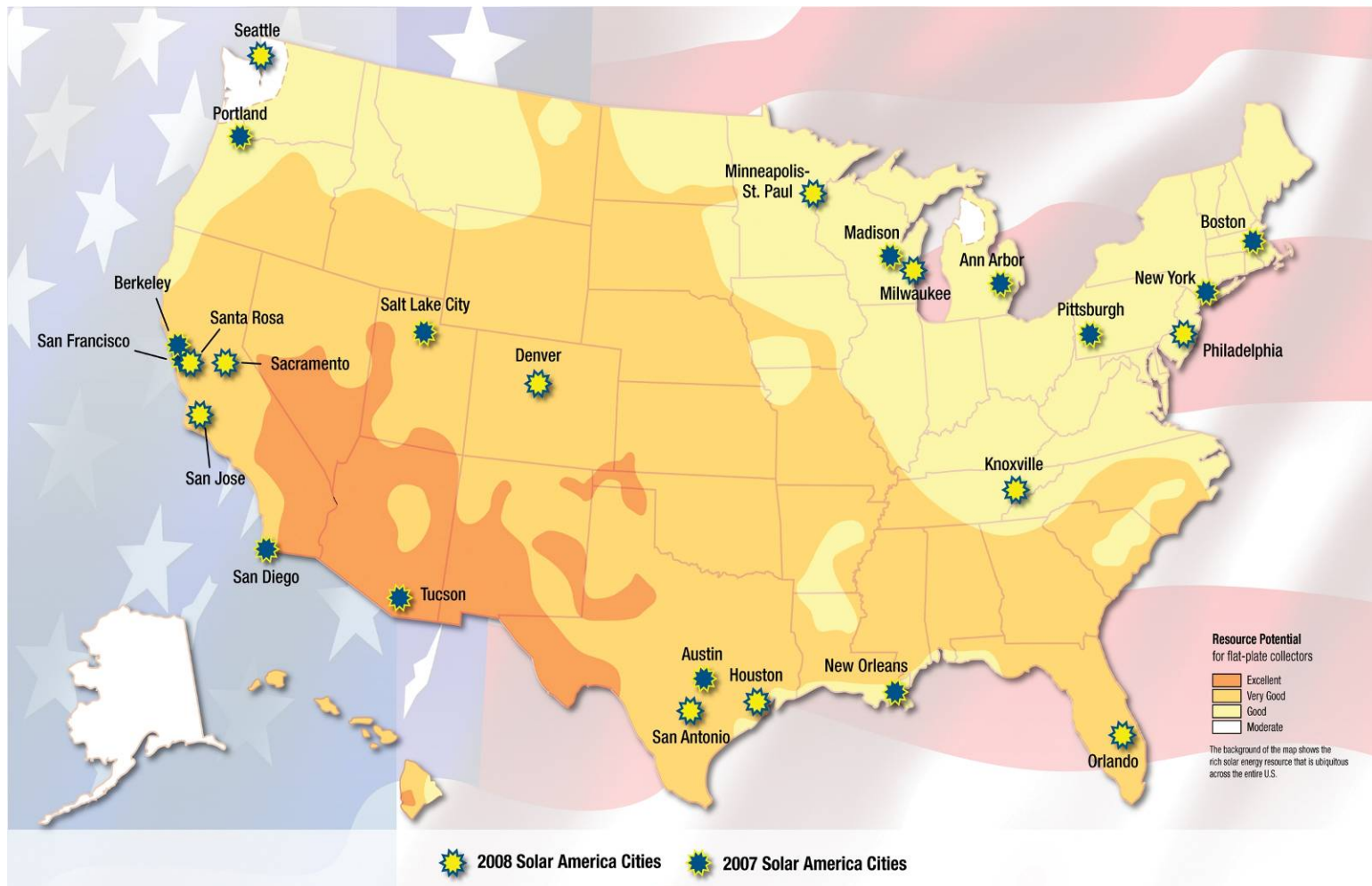
- Codes and Standards:**
 - Solar America Board of Codes and Standards (NM)
- Utility Technical Outreach:**
 - Solar Electric Power Association (DC)
- State Technical Outreach:**
 - Clean Energy Group (VT)
 - National Assn of Regulatory Utility Commissioners (DC)
 - National Conference of State Legislatures (CO)
- Solar America Cities:**
 - Ann Arbor (MI)
 - Austin (TX)
 - Berkeley (CA)
 - Boston (MA)
 - Madison (WI)
 - New Orleans (LA)
 - New York (NY)
 - Pittsburgh (PA)
 - Portland (OR)
 - Salt Lake City (UT)
 - San Diego (CA)
 - San Francisco (CA)
 - Tucson (AZ)

The Solar America Initiative (SAI) is accelerating the development of solar technologies, including photovoltaics (PV) and concentrating solar power (CSP) systems, with the goal of making them cost-competitive across all sectors by 2015. This work could not be successful without the collaboration of all stakeholders in the solar community. This map illustrates the location of several SAI participants... from Solar America City awardees who will be developing solar projects and building awareness in their respective communities to multinational corporations who will work in strategic alliances with other companies, national laboratories, and universities to tackle solar manufacturing challenges. It is truly a nationwide effort to create a Solar America.

Developing Products and Building Supply

- PV Capacity Credit Valuation Study:**
 - State University of New York (NY)
 - Tucson Electric Power (AZ)
- SAI Federal Projects:**
 - Architect of the Capitol (DC)
 - Smithsonian Institution (DC)
- Technology Pathway Partnerships:**
 - Amonix (CA)
 - Boeing (CA)
 - BP Solar (MD)
 - Dow Chemical (MI)
 - General Electric (DE)
 - GreenRay (MA)
 - Konarka (MA)
 - Nanosolar (CA)
 - Soliant (CA)
 - SunPower (CA)
 - United Solar Ovonic (MI)
- PV Module Incubator:**
 - AVA Solar (CO)
 - Blue Square Energy (MD)
 - CaliSolar (CA)
 - EnFocus Engineering (CA)
 - MicroLink Devices (IL)
 - Plextronics (PA)
 - PrimeStar Solar (CO)
 - Solaria (CA)
 - SolFocus (CA)
 - SoloPower (CA)

Solar America Cities

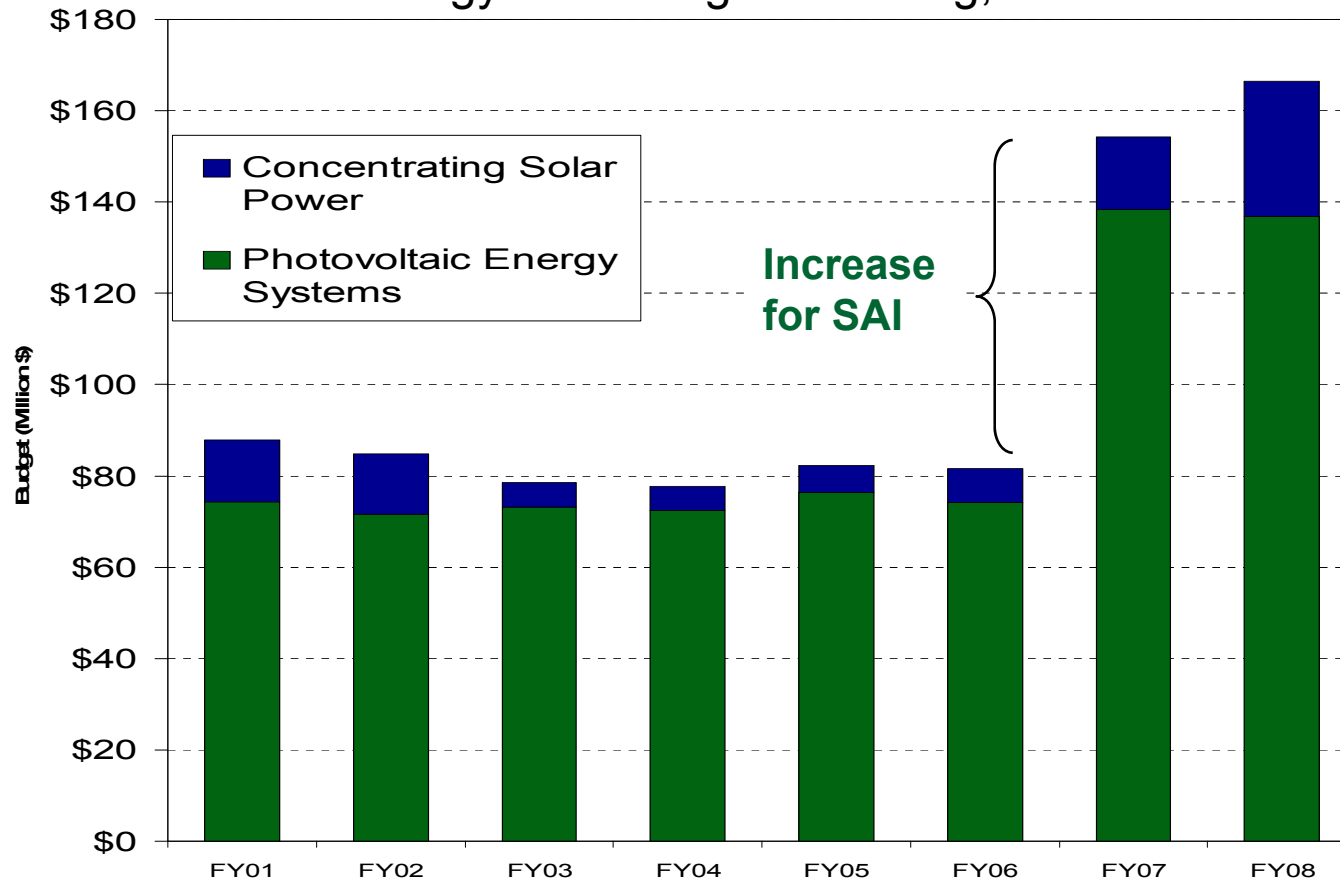


DOE's Solar America Cities will develop specific local solar infrastructure and deployment plans to provide models for other similarly situated localities

Funding for the Solar America Initiative will accelerate supply growth & adoption of PV/CSP technologies



Solar Energy Technologies Funding, FY01 – FY08



- Funding is issued through competitive grants to Labs, Industry, University, Municipalities

The SAI is intended to realize the full value of 30-years of RD&D with a major clean energy source.

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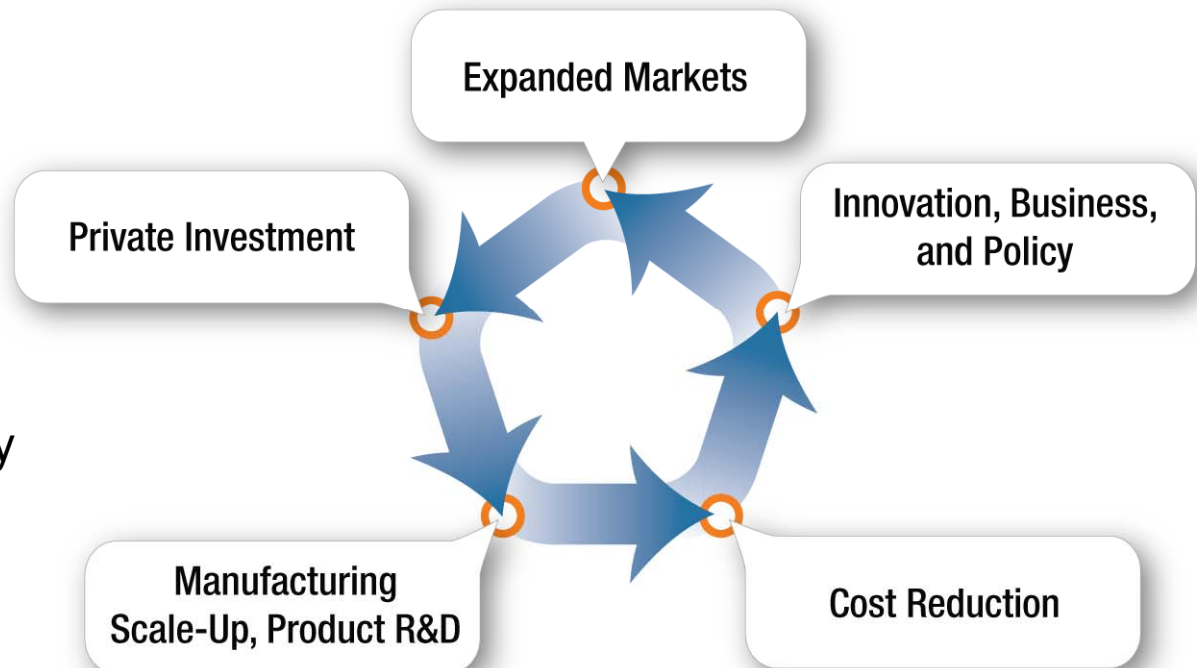
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Technology and business innovation stimulates public and private investment, which commences a virtuous cycle of market expansion



- In order to achieve SAI goals; solar investors and companies must execute and perpetuate this cycle
- Policy supports are only in place for a limited duration, and the recent rapid expansion of investment in solar is maximizing the utility of these incentives while they last
- More mature, larger markets emerge from the end of the early market hypergrowth stage

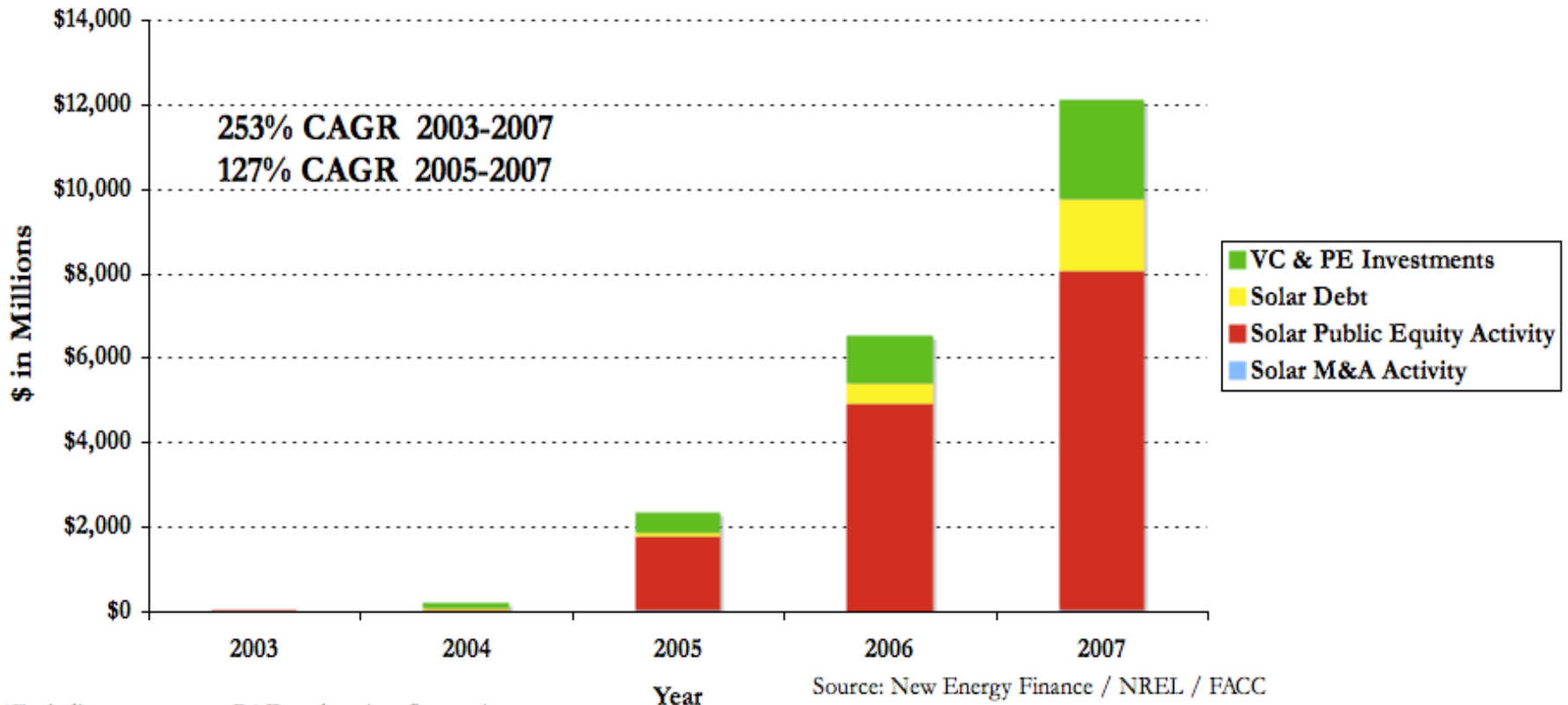
Positive Feedback for PV



Global investment in solar companies has grown exponentially, and that growth is expected to continue



Global Capital Invested in Solar Energy*



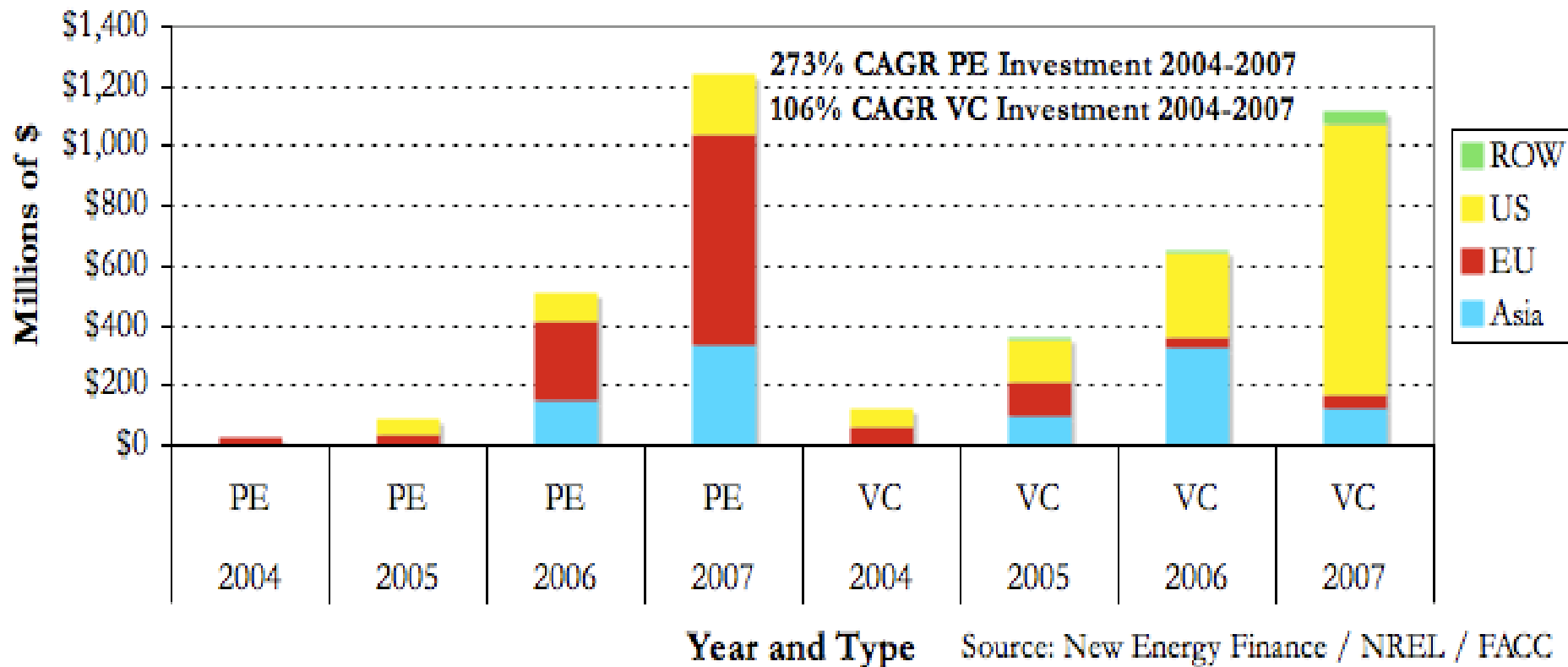
*Excluding government R&D and project finance investments

Despite a pull back in share prices of public equities, solar companies have continued to raise significant capital throughout Q1 2008.

Venture capital and private equity investments have created new companies and capacity expansions



Global Venture Capital and Private Equity Investment in Solar

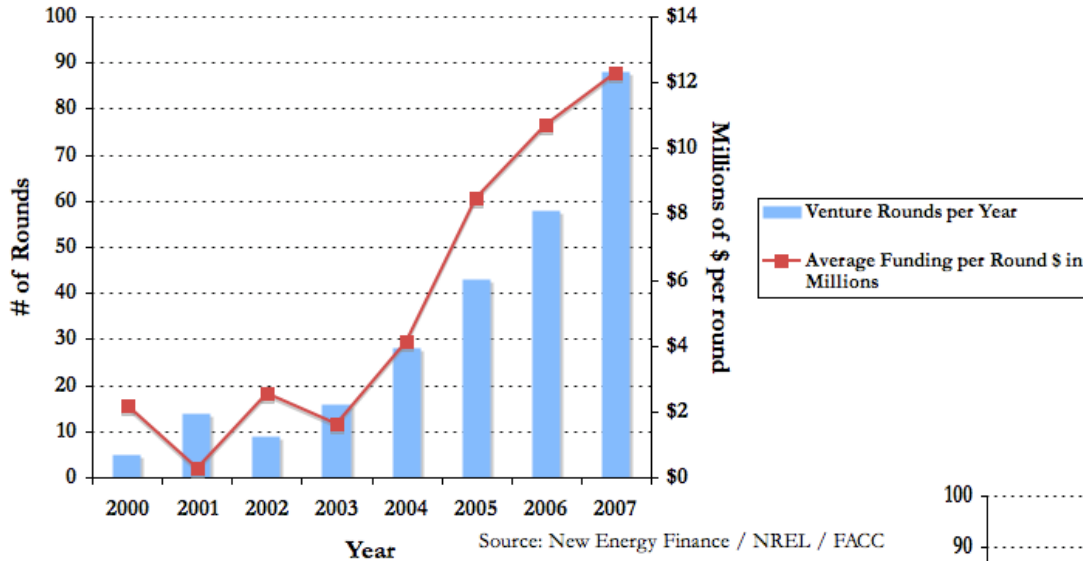


In 2007, capacity expansions (private equity investments) dominated in the EU, while the U.S. venture community dramatically ramped up funding of start - ups

Venture capital deal flow has expanded, including increases in deal size and volume



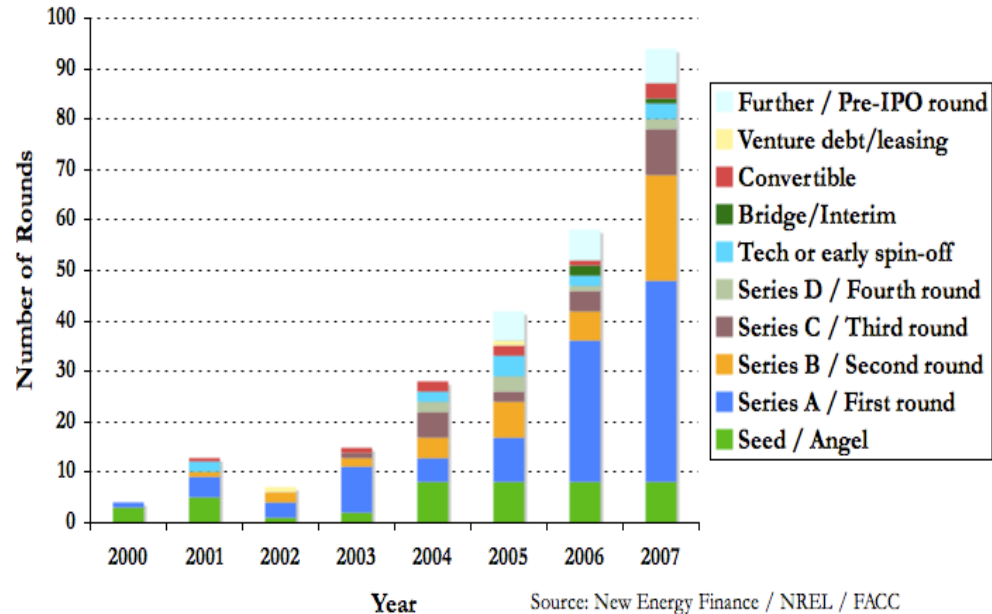
Venture Capital Rounds and Average Round Amount



- As companies have matured, and venture investors have recognized the longer time period required for energy investments, deal size has increased

- Venture round growth from 2005 through 2007 shows significant increases in first and second round deals, showing that the market for new solar innovations has not been sated

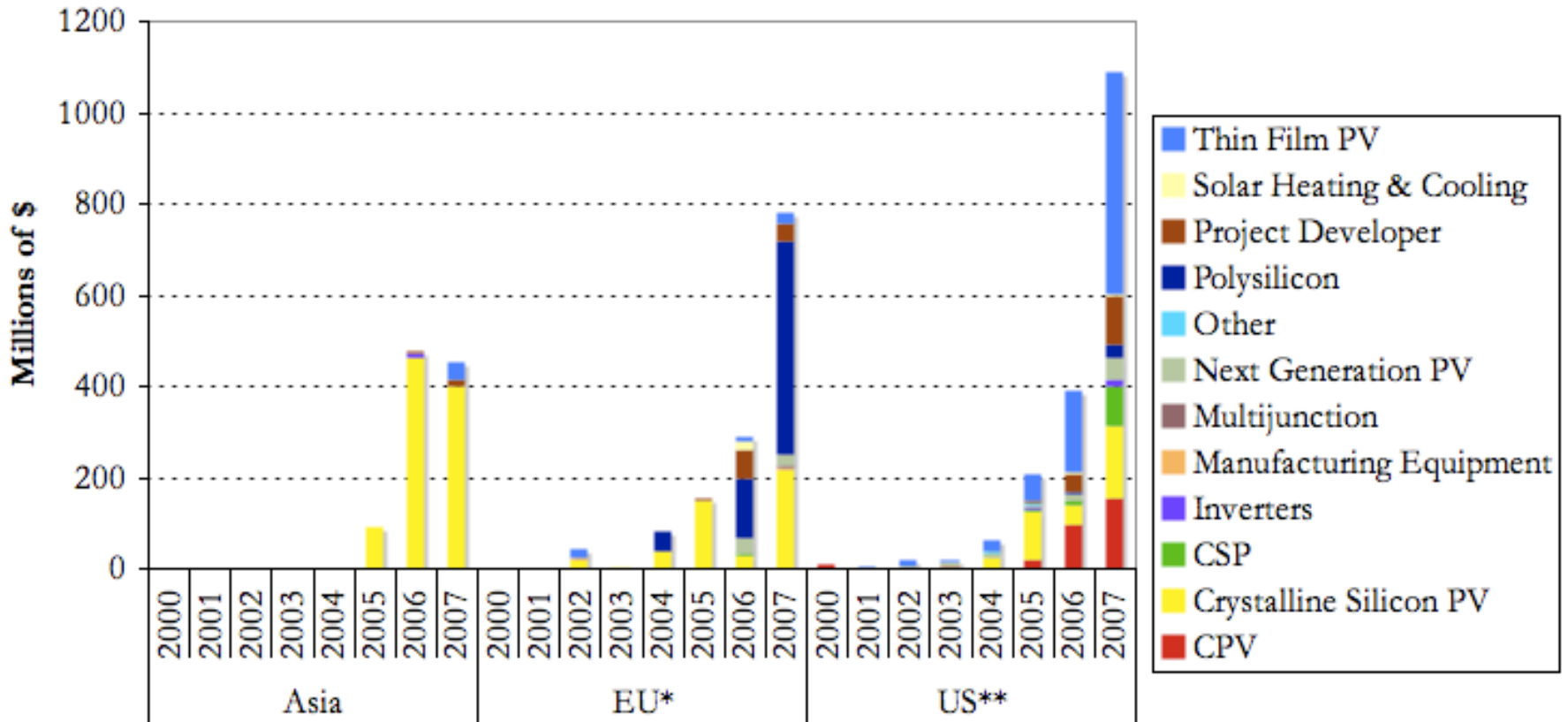
Venture Capital Funding by Round Type



Private investments by solar technology type show significant regional variances and specializations



Global Private Investment by Solar Technology



*EU includes Israel

**U.S. includes Australia and Canada

Region / Year

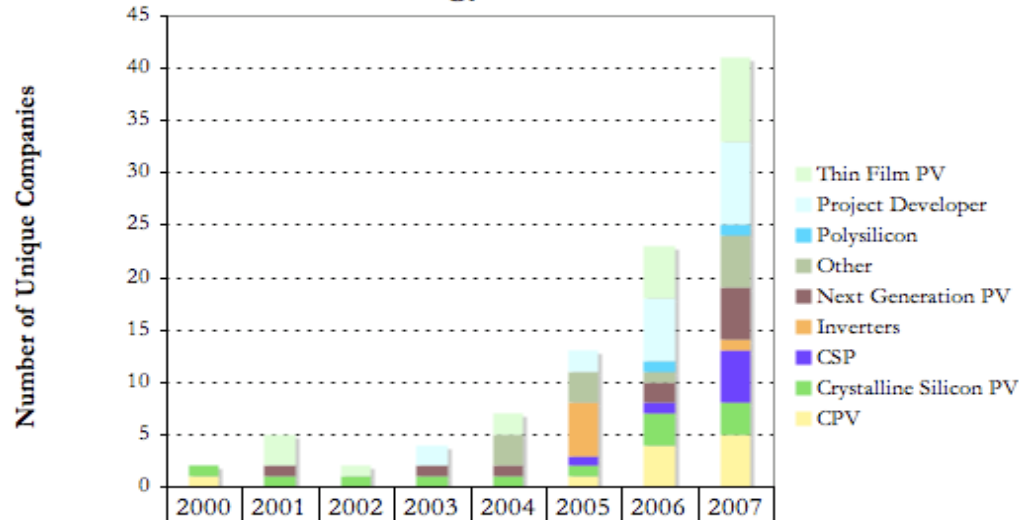
Source: New Energy Finance / NREL / FACC

Regional patterns of investment are likely to change as newer technologies mature and are migrated to lower cost manufacturing centers

Many U.S. solar companies are making significant cost and quality improvements to their technologies



Unique US Solar Companies Receiving Private Investment by Technology Area



	2000	2001	2002	2003	2004	2005	2006	2007
Thin Film PV		3	1		2		5	8
Project Developer				2		2	6	8
Polysilicon							1	1
Other					3	3	1	5
Next Generation PV		1		1	1		2	5
Inverters						5		1
CSP						1	1	5
Crystalline Silicon PV	1	1	1	1	1	1	3	3
CPV	1					1	4	5

Year

Source: NEF / NREL / FACC

- All of these companies are pursuing 'grid parity' or economic competitiveness.
- Many firms calculate 'grid parity' with approximately 10 c/kWh electricity calculated over the life of the solar system.

DOE and these companies' investors believe that many of their technologies will reach 'grid parity' by 2015 or sooner.

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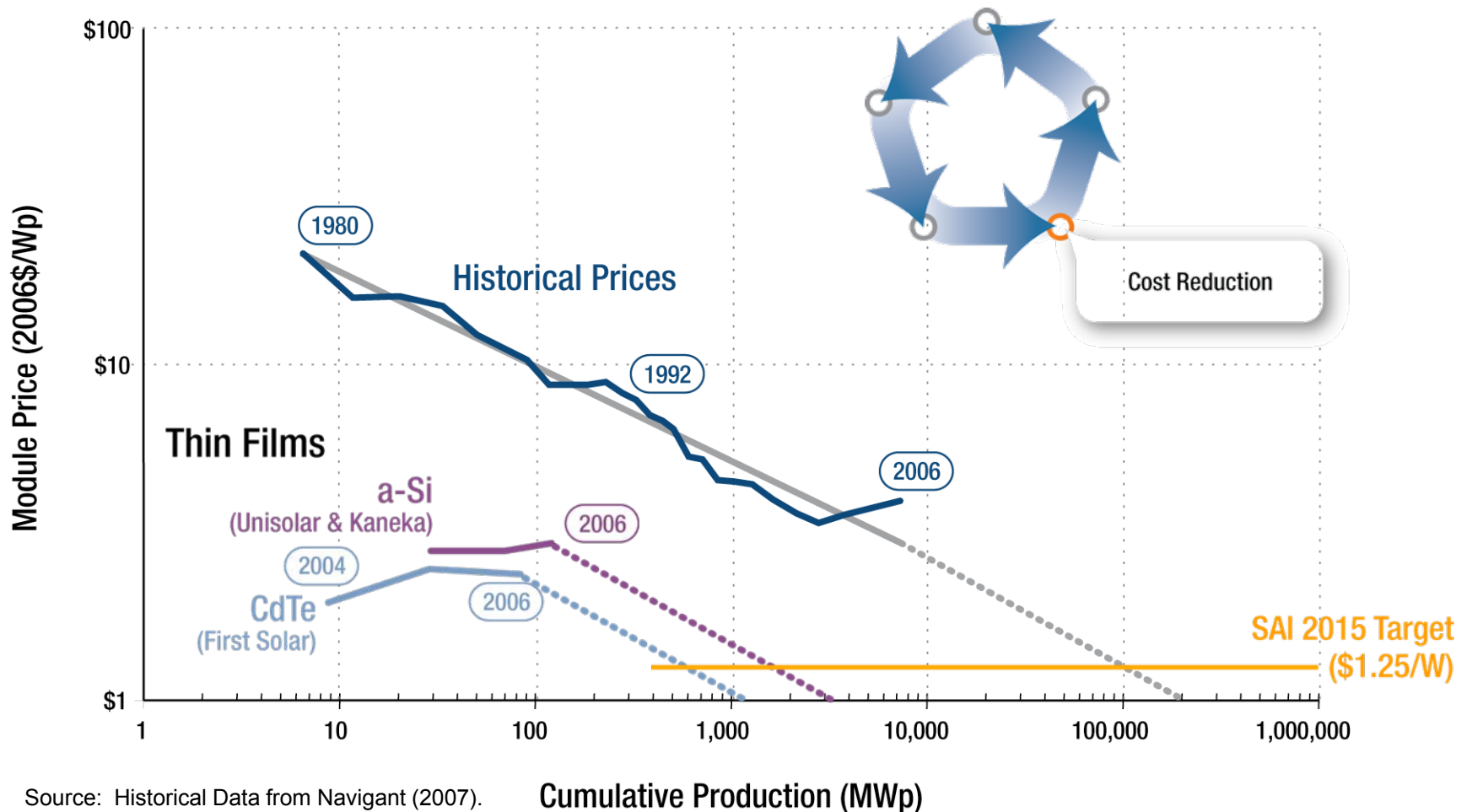


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Experience shows that as solar manufacturing increases, module costs are reduced significantly

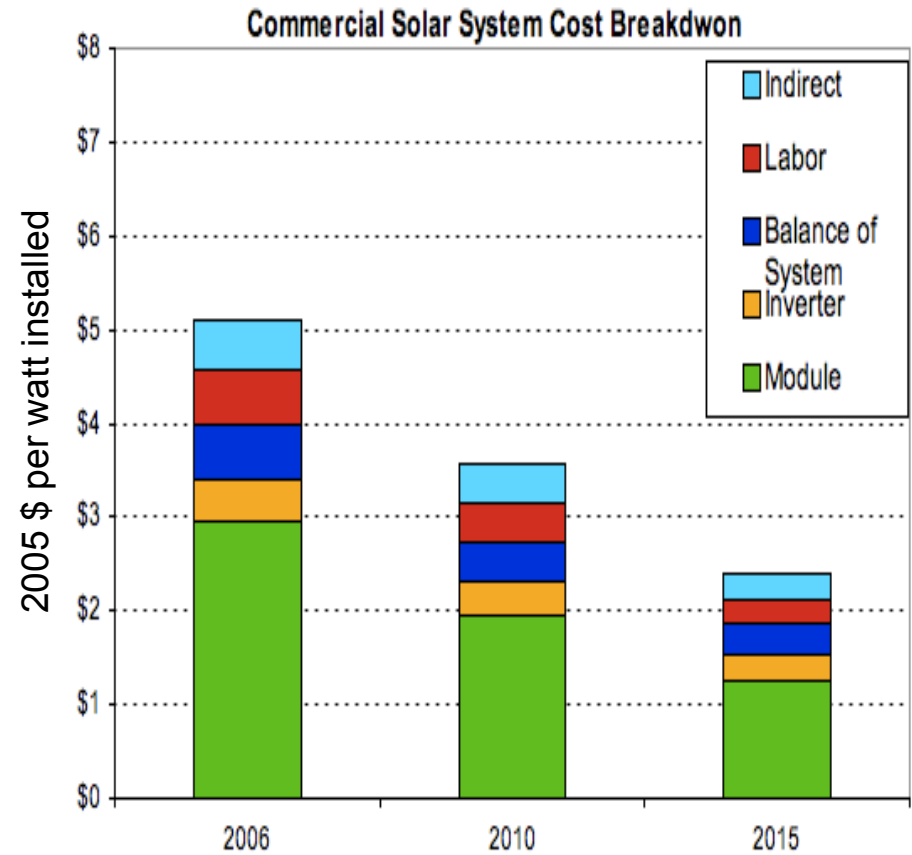
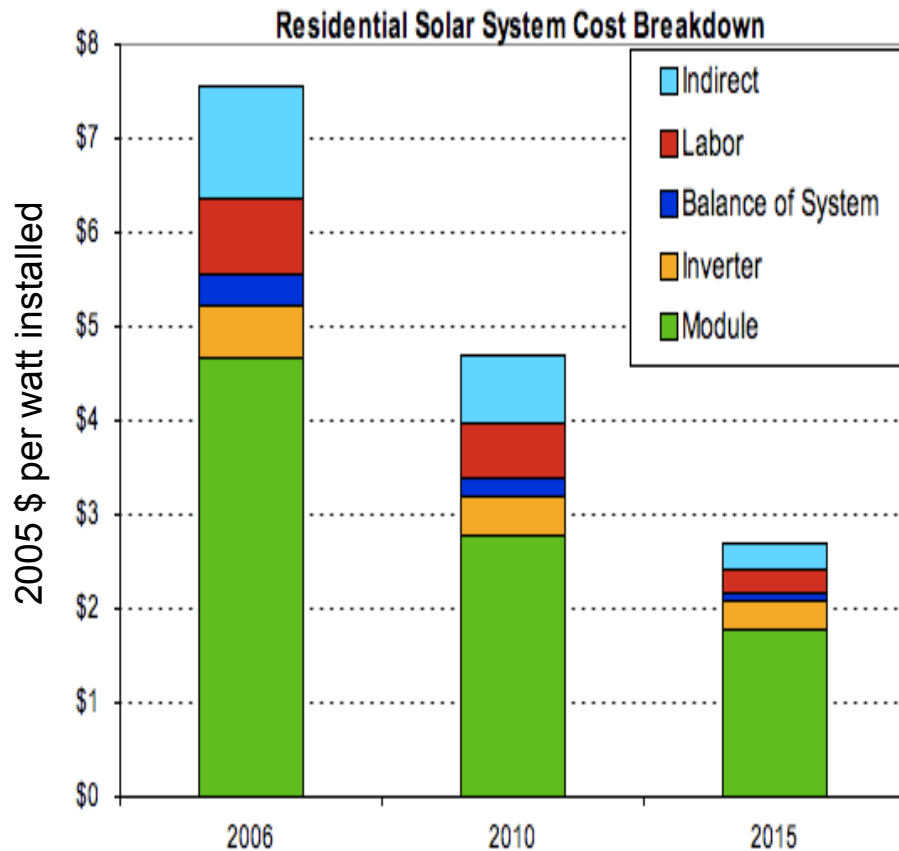


Historical and Projected Experience Curve for PV Modules



Source: Historical Data from Navigant (2007).

But, the module is not all of the cost - DOE SAI industry partner installed system cost projections



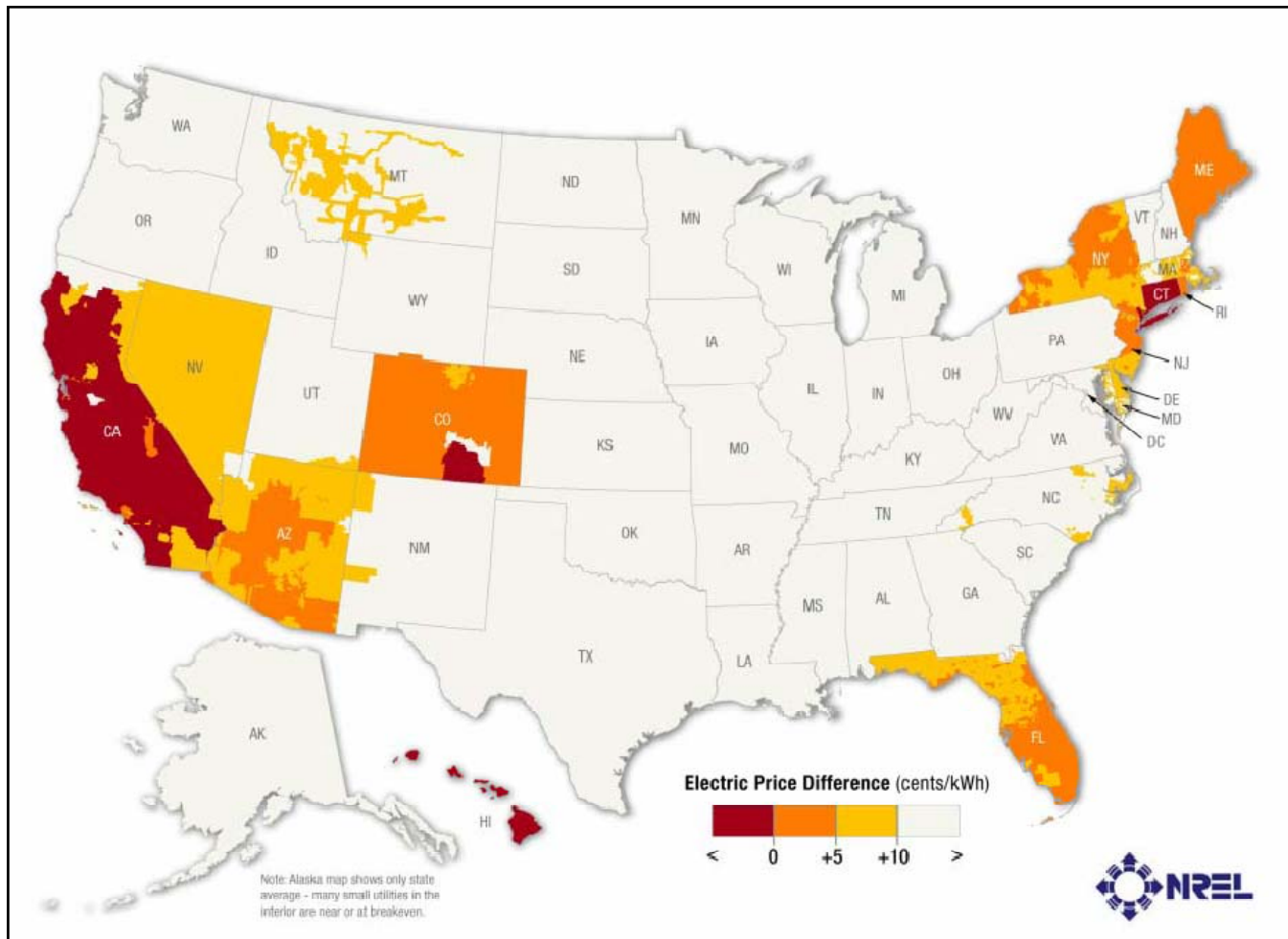
- Note the high level of indirect and labor costs - these are driven by regulatory, educational and financing hurdles (non-R&D).

Established solar manufacturers are realizing cost reductions across the value chain and will reduce installed system cost by approximately 50% by 2015

Market penetration begins - 2007 residential PV and electricity price differences with existing incentives



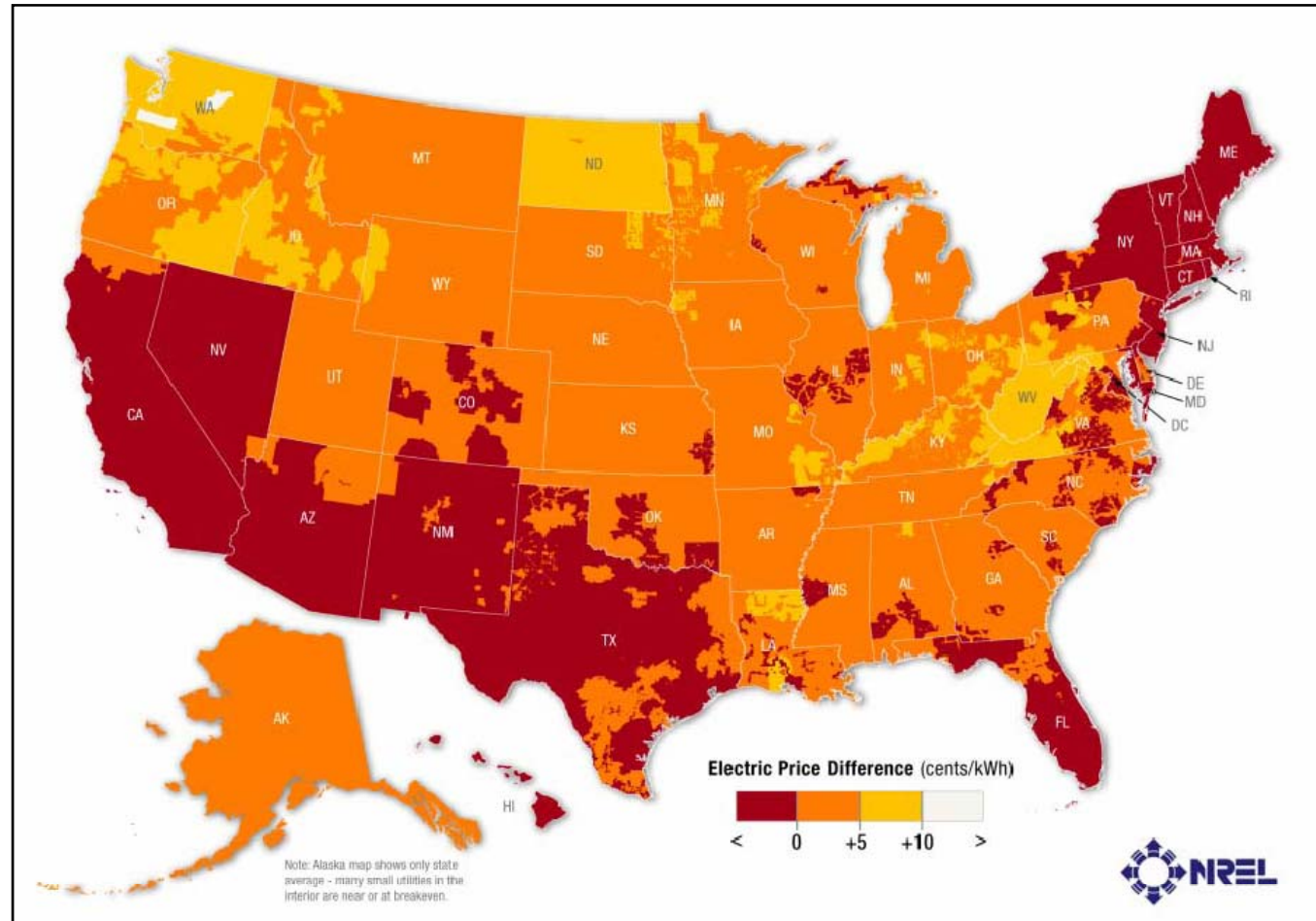
- Currently PV is financially competitive where there is some combination of high electricity prices, excellent sunshine and/or state/local incentives.



Solar acceleration in a conservative forecast - 2015 residential without incentives and moderate increase in electricity prices



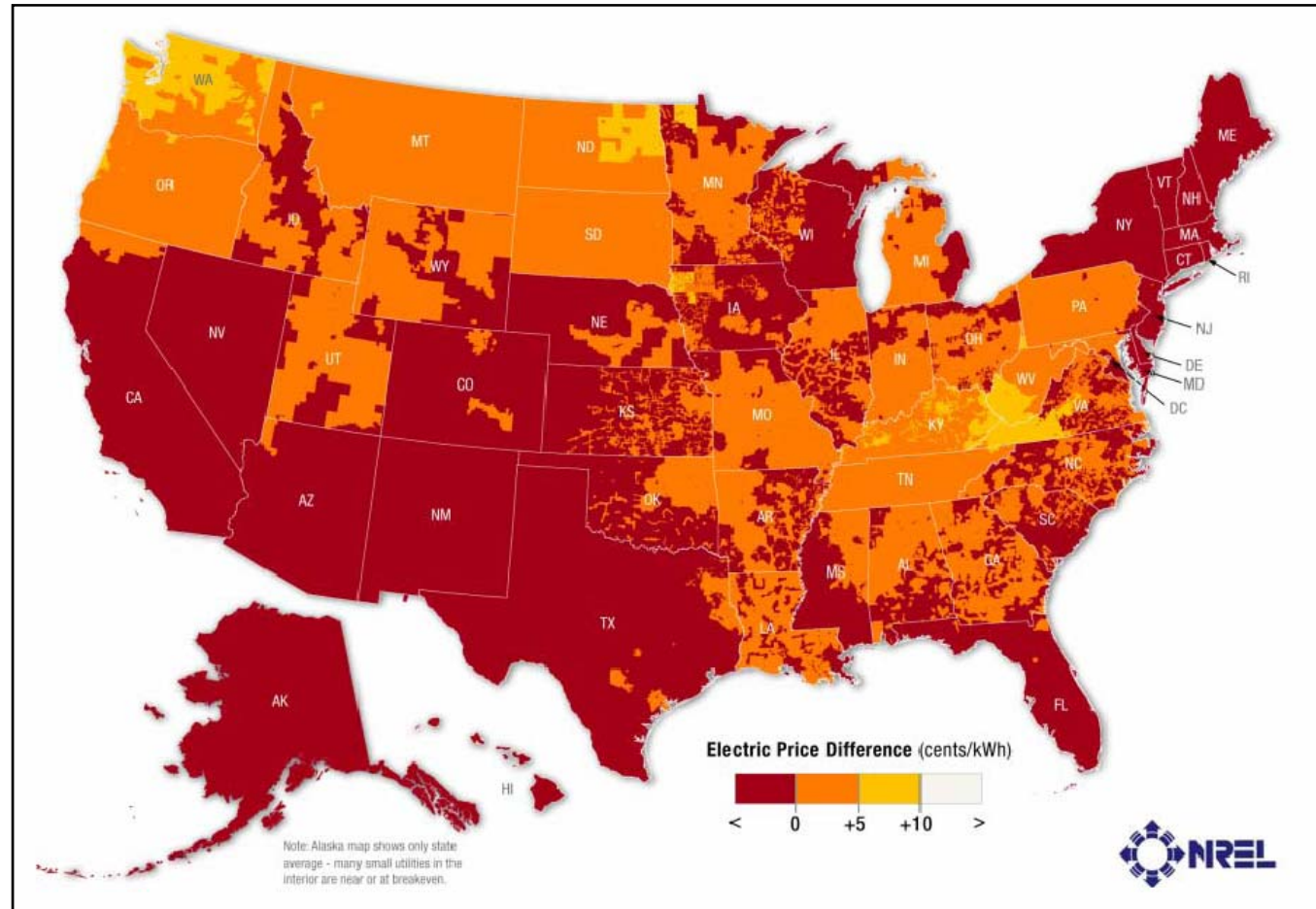
- Attractive in about 250 of 1,000 largest utilities, which provide ~37% of U.S. residential electricity sales.
- 85% of sales (in nearly 870 utilities) are projected to have a price difference of less than 5 ¢/kWh between PV and grid electricity.
- In large areas, PV is cheaper than grid electricity



2015 residential installations without incentives and aggressive increase in electricity prices



- Attractive in about 450 of 1,000 largest utilities, which provide ~50% of U.S. residential electricity sales.
- 91% of sales (in nearly 950 utilities) have a price difference of less than 5 ¢/kWh between PV and grid electricity.
- Across most of the highest U.S. population areas, PV is cheaper than grid electricity.



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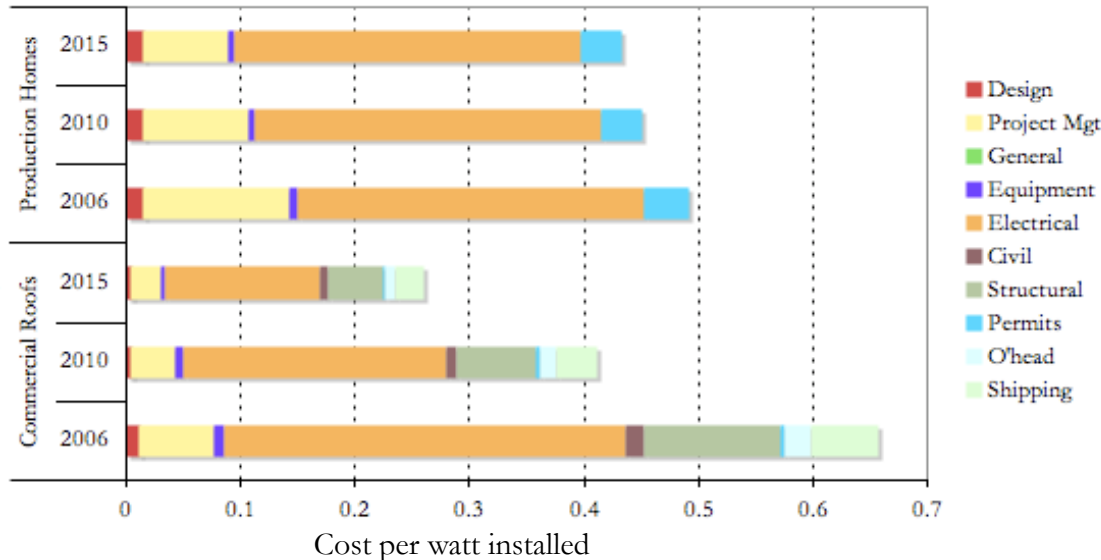


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Balance of system / installation costs will fall as policy becomes more solar friendly



Breakdown of installation costs



- State/local governments and utilities can have major impacts on the local price of solar electricity by impacting installation costs

- Solar production is global but every installation is local

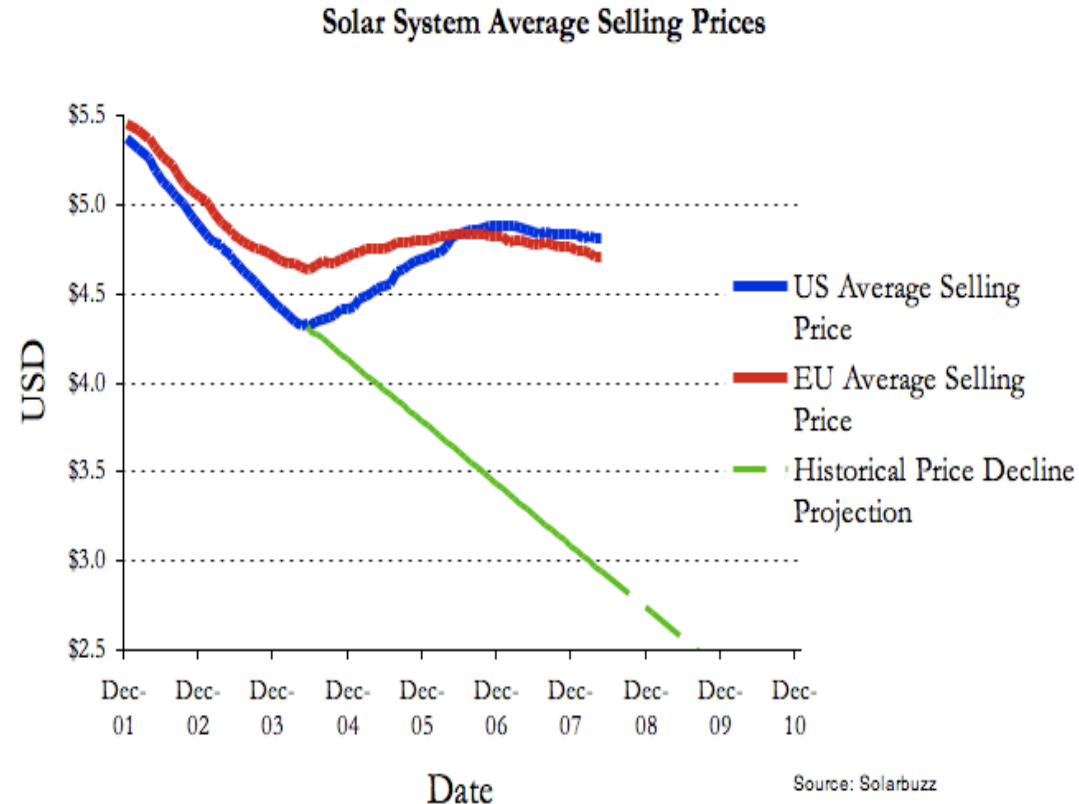
State/local governments and utilities can promote solar by:

- streamlining solar permitting
- facilitating interconnection to the grid
- establishing solar-friendly net metering regulations
- banning homeowner association restrictions against solar
- establishing installer and code official training centers at community colleges
- offering tax incentives (sales, income, property) to solar purchasers
- creating public outreach and information campaigns

A recent shortage in silicon, a major PV feedstock, has driven up the cost of PV over the past few years.



- Generous subsidy programs in Europe have pushed up worldwide solar demand and caused prices to rise over the past few years
- Large amounts of new silicon production are coming online in the next year.
- Established silicon manufacturing companies like Cypress Semiconductor, Applied Materials, Hemlock, Wacker Chemie, and MEMC Electronic Devices are expanding rapidly into the industry
- The DOE Solar Program believes this to be a short-term problem that will be alleviated by 2010.



If robust policy is in place when the silicon shortage ends, and cost and price return to 'normal' levels, large numbers of economical PV installations will occur

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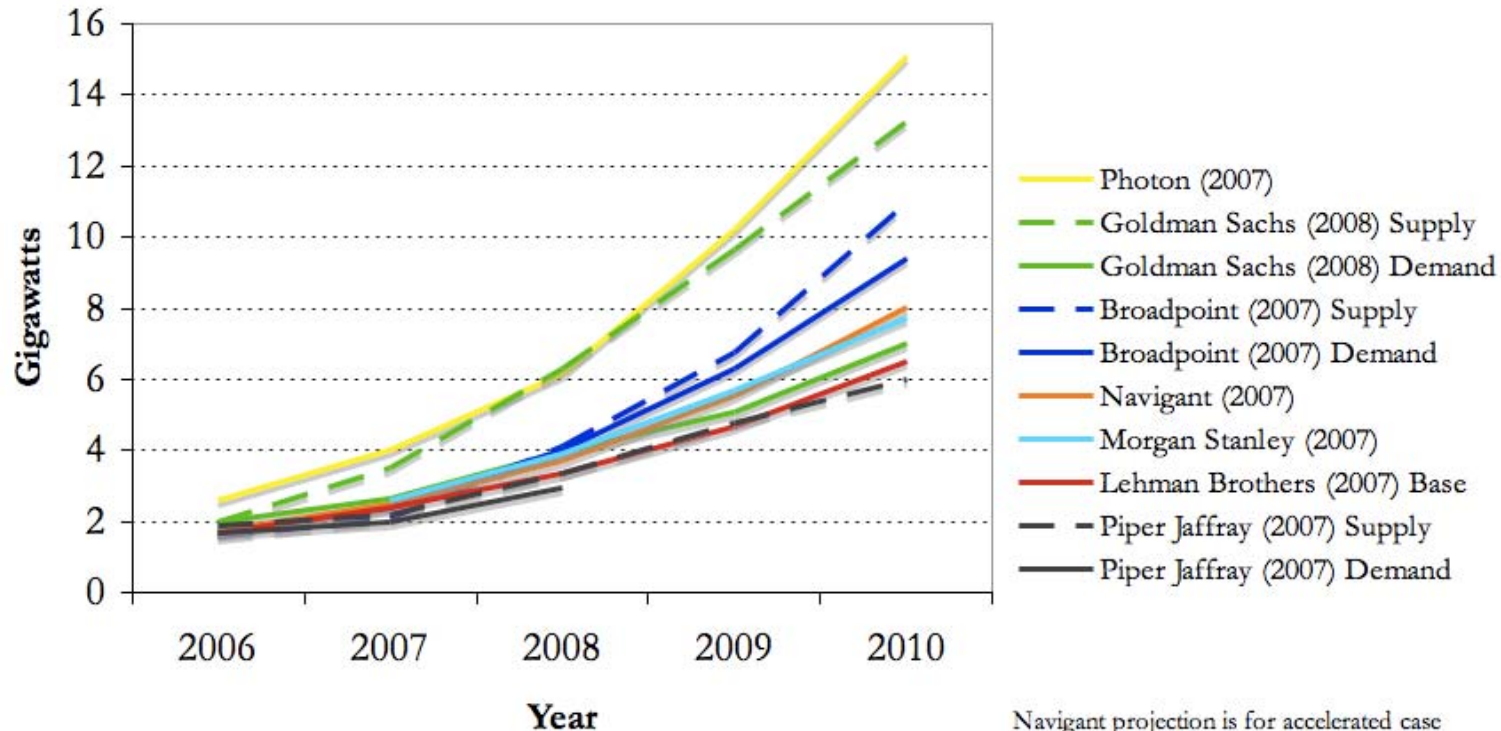


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Industry analysts' market forecasts



Global Projected PV Market



Navigant projection is for accelerated case
Source: Company analyst reports / FACC

- The DOE Solar Program projects with certainty that the most conservative of these projections (Piper Jaffray 2007) will be met
- We are currently analyzing the results from our own market interactions to determine a band of realistic projections to be released later in 2008.
- We expect that band to comfortably fall within the industry projections parameters shown above.

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For More Information:

DOE Solar Program: http://www.eere.energy.gov/solar/solar_america/
PV Value Clearinghouse: www.nrel.gov/analysis/pvclearinghouse/
SNL PV Systems R&D: www.sandia.gov/pv
NREL Solar Research: www.nrel.gov/solar

To sign up for our Newsletter and Market Analysis or for any questions on this presentation, email solar@ee.doe.gov

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