Envisioning the Solar Program Beyond the Solar America Initiative (SAI)

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Agenda

- Overview of the SAI
- Rationalizing the SAI goals
- Rapidly evolving investment environment
- Positive feedback loop for solar
- Where do we go from here?

  – Origins and status of the SAI

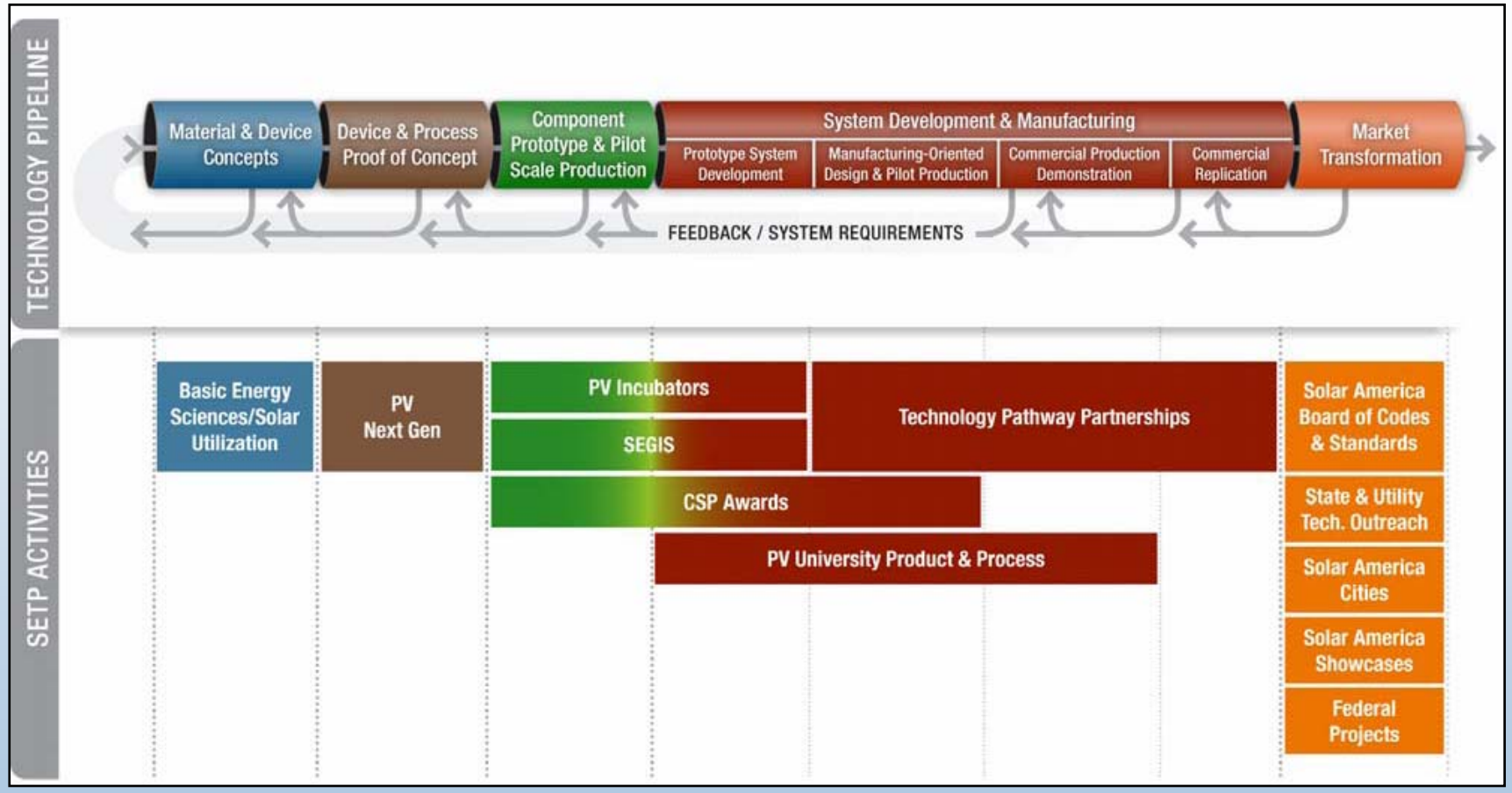
SAI timeline

- Launching SAI:
  - Summer 2005: Initial proposal for SAI drafted.
  - Fall 2005: Refined rationale for, structure of, and benefits estimates of SAI in order to build support within administration.
  - January 2006. President included SAI in State of Union address and in FY07 budget request to Congress.
  - April 2006. TPP Technical Exchange Meeting held in Chicago, IL.
  - June 2006. TPP Funding Opportunity Announcement (FOA) issued.
- Series of awards announced during 2007/8.
  - March 2007. TPP awards.
  - June 2007. Incubator awards.
  - November 2007. Next Gen awards.
  - November 2007. Concentrating Solar Power awards.
  - March 2008. University Product and Process Development awards.
- Additional awards announced/in process.
  - December 2007. Solar Energy Grid-Integration FOA.
  - April 2008. Second round of incubators FOA.
  - Coming soon. Supply Chain FOA…

Evolving technical performance and industry structure led to changes in the Solar Program's goals & strategy

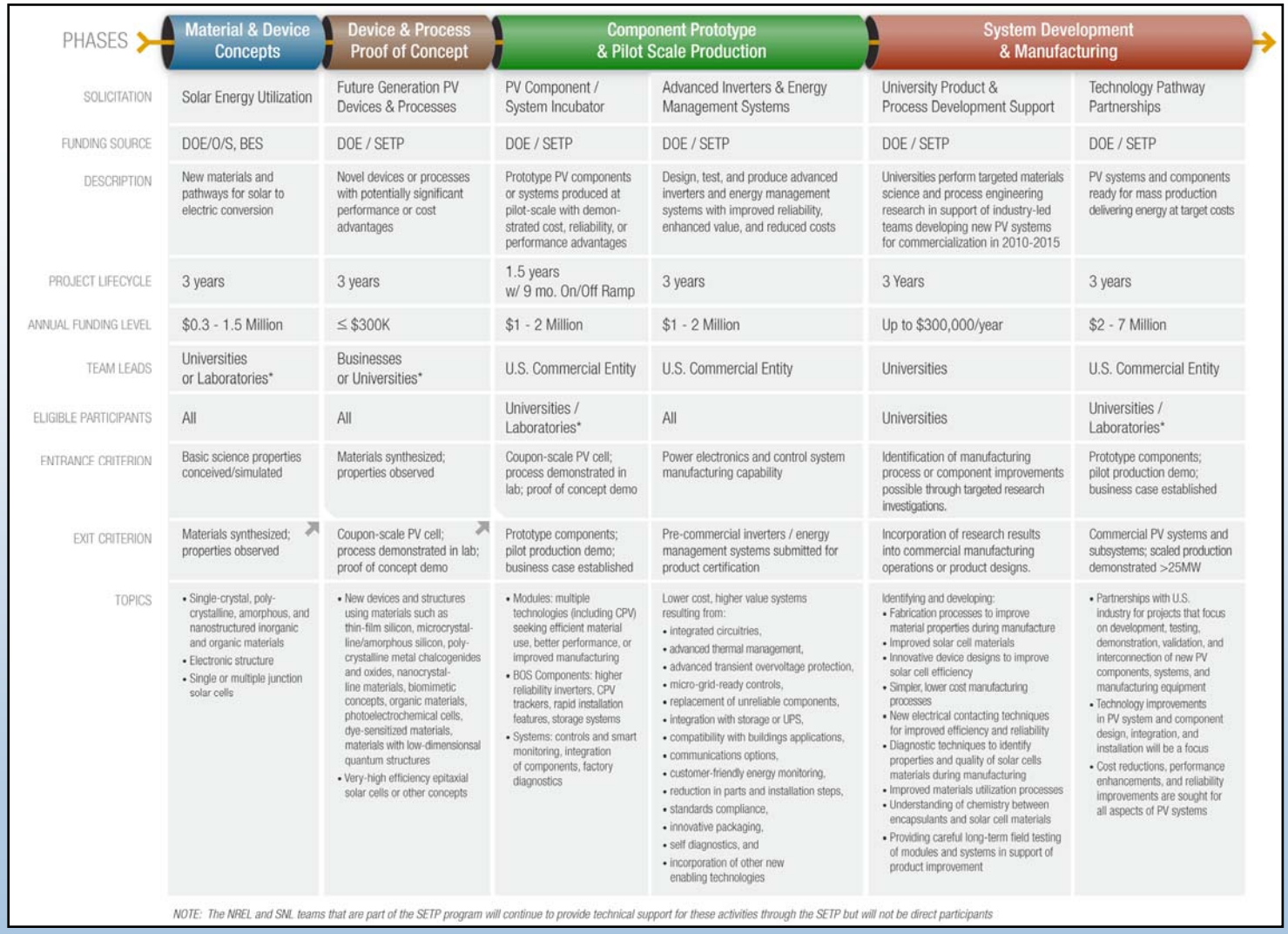
	PRE-SAI	SAI
Research Focus	Technical improvements to individual components	Technical improvements to integrated PV systems
Performers, R&D Agenda	• National Labs drive R&D to enabling efficiency/cost requirements • Companies and universities get help maturing technology	• Companies develop products for priority market applications • Industry influences Lab/university research agenda
Program Goal Date	2020	2015
Pace of Progress	Incremental progress through stable laboratory funding	Substantial progress driven by large competitive solicitation and aggressive downselect process
R&D Funding Approach	Individual projects at National Labs, Universities, and Companies	System projects with multiple value-chain partners, Individual projects for earlier-stage technologies
Technology Acceptance	Large number of small-scale projects that generate local interest	Small number of large-scale, high-visibility projects that will help lower PV market barriers

The SAI R&D pipeline



- The initial emphasis of the SAI has been on filling in the R&D pipeline for PV, however, SAI is currently being expanded to include CSP and grid-integration.

The SAI PV R&D pipeline

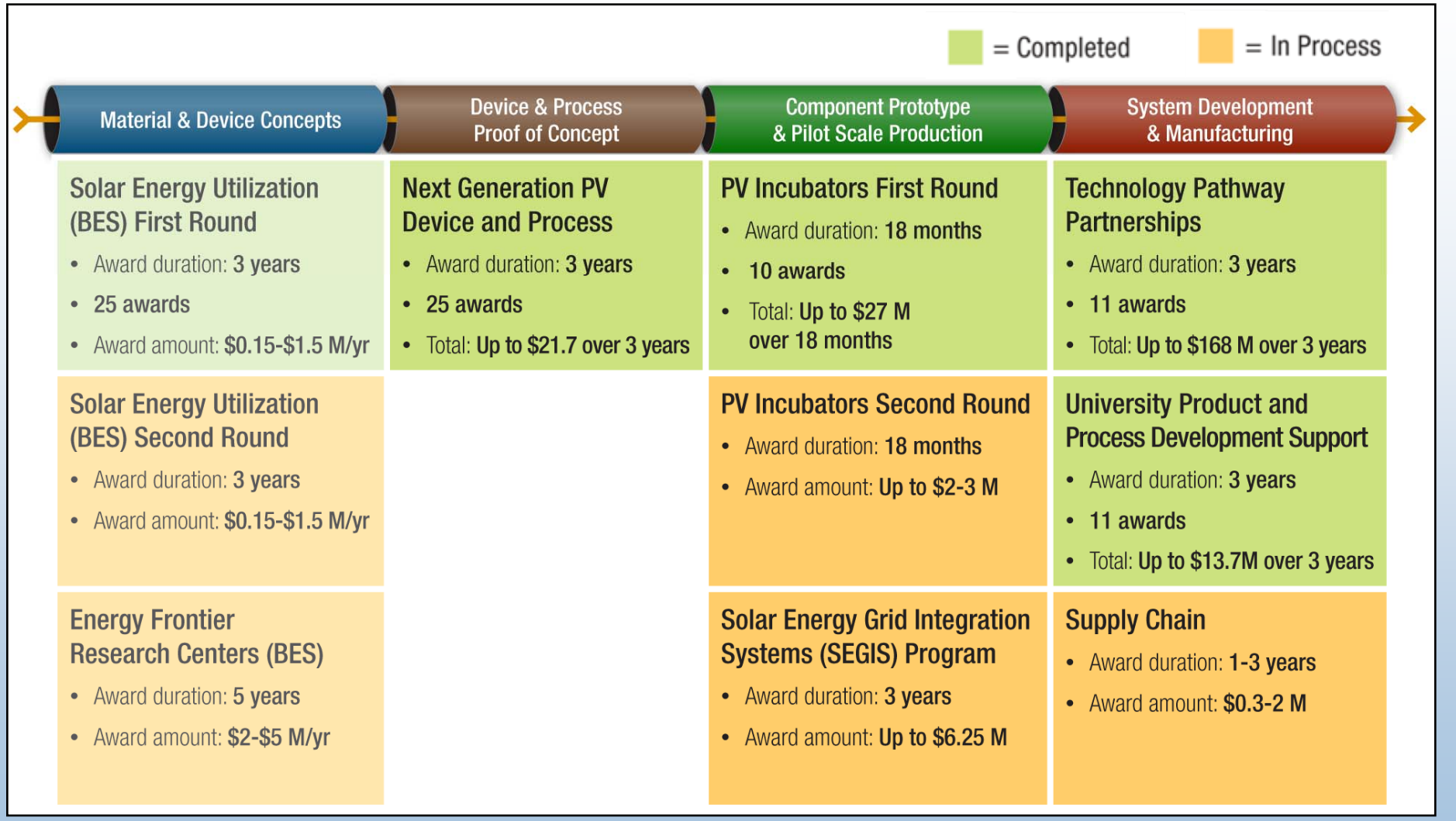


PHASES	Material & Device Concepts	Device & Process Proof of Concept	Component Prototype & Pilot Scale Production		System Development & Manufacturing	
SOLICITATION	Solar Energy Utilization	Future Generation PV Devices & Processes	PV Component / System Incubator	Advanced Inverters & Energy Management Systems	University Product & Process Development Support	Technology Pathway Partnerships
FUNDING SOURCE	DOE/O/S, BES	DOE / SETP	DOE / SETP	DOE / SETP	DOE / SETP	DOE / SETP
DESCRIPTION	New materials and pathways for solar to electric conversion	Novel devices or processes with potentially significant performance or cost advantages	Prototype PV components or systems produced at pilot-scale with demonstrated cost, reliability, or performance advantages	Design, test, and produce advanced inverters and energy management systems with improved reliability, enhanced value, and reduced costs	Universities perform targeted materials science and process engineering research in support of industry-led teams developing new PV systems for commercialization in 2010-2015	PV systems and components ready for mass production delivering energy at target costs
PROJECT LIFECYCLE	3 years	3 years	1.5 years w/ 9 mo. On/Off Ramp	3 years	3 Years	3 years
ANNUAL FUNDING LEVEL	$0.3 - 1.5 Million	≤ $300K	$1 - 2 Million	$1 - 2 Million	Up to $300,000/year	$2 - 7 Million
TEAM LEADS	Universities or Laboratories*	Businesses or Universities*	U.S. Commercial Entity	U.S. Commercial Entity	Universities	U.S. Commercial Entity
ELIGIBLE PARTICIPANTS	All	All	Universities / Laboratories*	All	Universities	Universities / Laboratories*
ENTRANCE CRITERION	Basic science properties conceived/simulated	Materials synthesized; properties observed	Coupon-scale PV cell; process demonstrated in lab; proof of concept demo	Power electronics and control system manufacturing capability	Identification of manufacturing process or component improvements possible through targeted research investigations.	Prototype components; pilot production demo; business case established
EXIT CRITERION	Materials synthesized; properties observed	Coupon-scale PV cell; process demonstrated in lab; proof of concept demo	Prototype components; pilot production demo; business case established	Pre-commercial inverters / energy management systems submitted for product certification	Incorporation of research results into commercial manufacturing operations or product designs.	Commercial PV systems and subsystems; scaled production demonstrated >25MW
TOPICS	• Single-crystal, poly-crystalline, amorphous, and nanostructured inorganic and organic materials • Electronic structure • Single or multiple junction solar cells	• New devices and structures using materials such as thin-film silicon, microcrystal-line/amorphous silicon, poly-crystalline metal chalcogenides and oxides, nanocrystal-line materials, biomimetic concepts, organic materials, photoelectrochemical cells, dye-sensitized materials, materials with low-dimensional quantum structures • Very-high efficiency epitaxial solar cells or other concepts	• Modules: multiple technologies (including CPV) seeking efficient material use, better performance, or improved manufacturing • BOS Components: higher reliability inverters, CPV trackers, rapid installation features, storage systems • Systems: controls and smart monitoring, integration of components, factory diagnostics	Lower cost, higher value systems resulting from: • integrated circuitries, • advanced thermal management, • advanced transient overvoltage protection, • micro-grid-ready controls, • replacement of unreliable components, • integration with storage or UPS, • compatibility with buildings applications, • communications options, • customer-friendly energy monitoring, • reduction in parts and installation steps, • standards compliance, • innovative packaging, • self diagnostics, and • incorporation of other new enabling technologies	Identifying and developing: • Fabrication processes to improve material properties during manufacture • Improved solar cell materials • Innovative device designs to improve solar cell efficiency • Simpler, lower cost manufacturing processes • New electrical contacting techniques for improved efficiency and reliability • Diagnostic techniques to identify properties and quality of solar cells materials during manufacturing • Improved materials utilization processes • Understanding of chemistry between encapsulants and solar cell materials • Providing careful long-term field testing of modules and systems in support of product improvement	• Partnerships with U.S. industry for projects that focus on development, testing, demonstration, validation, and interconnection of new PV components, systems, and manufacturing equipment • Technology improvements in PV system and component design, integration, and installation will be a focus • Cost reductions, performance enhancements, and reliability improvements are sought for all aspects of PV systems

NOTE: The NREL and SNL teams that are part of the SETP program will continue to provide technical support for these activities through the SETP but will not be direct participants

- Supporting technologies /companies, through a series of funding opportunities calibrated to their level of maturity.

Current status of SAI R&D solicitations



- SAI solicitations complement increasing support from DOE's Office of Basic Energy Sciences (BES).

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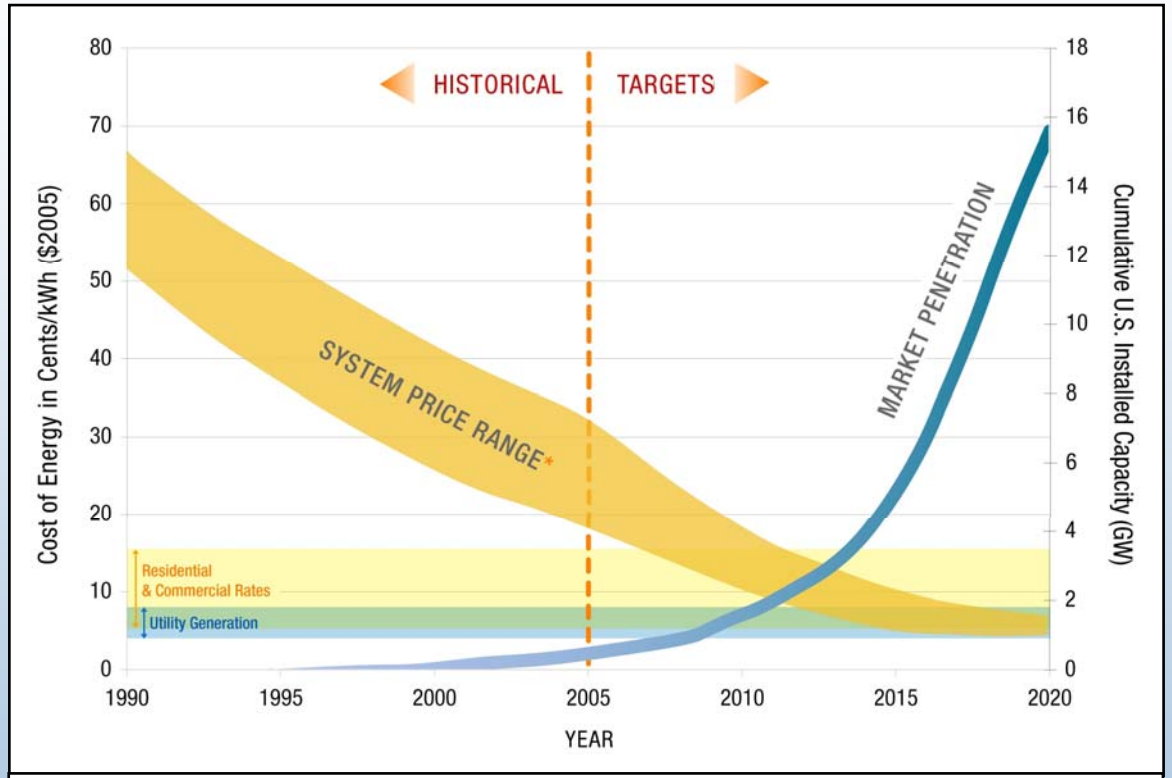
- Rapidly evolving investment environment
- Positive feedback loop for solar
- Where do we go from here?
  - Achieving a self-sustaining market

Expect to reach grid parity in U.S. between 2010 and 2015

But many challenges:

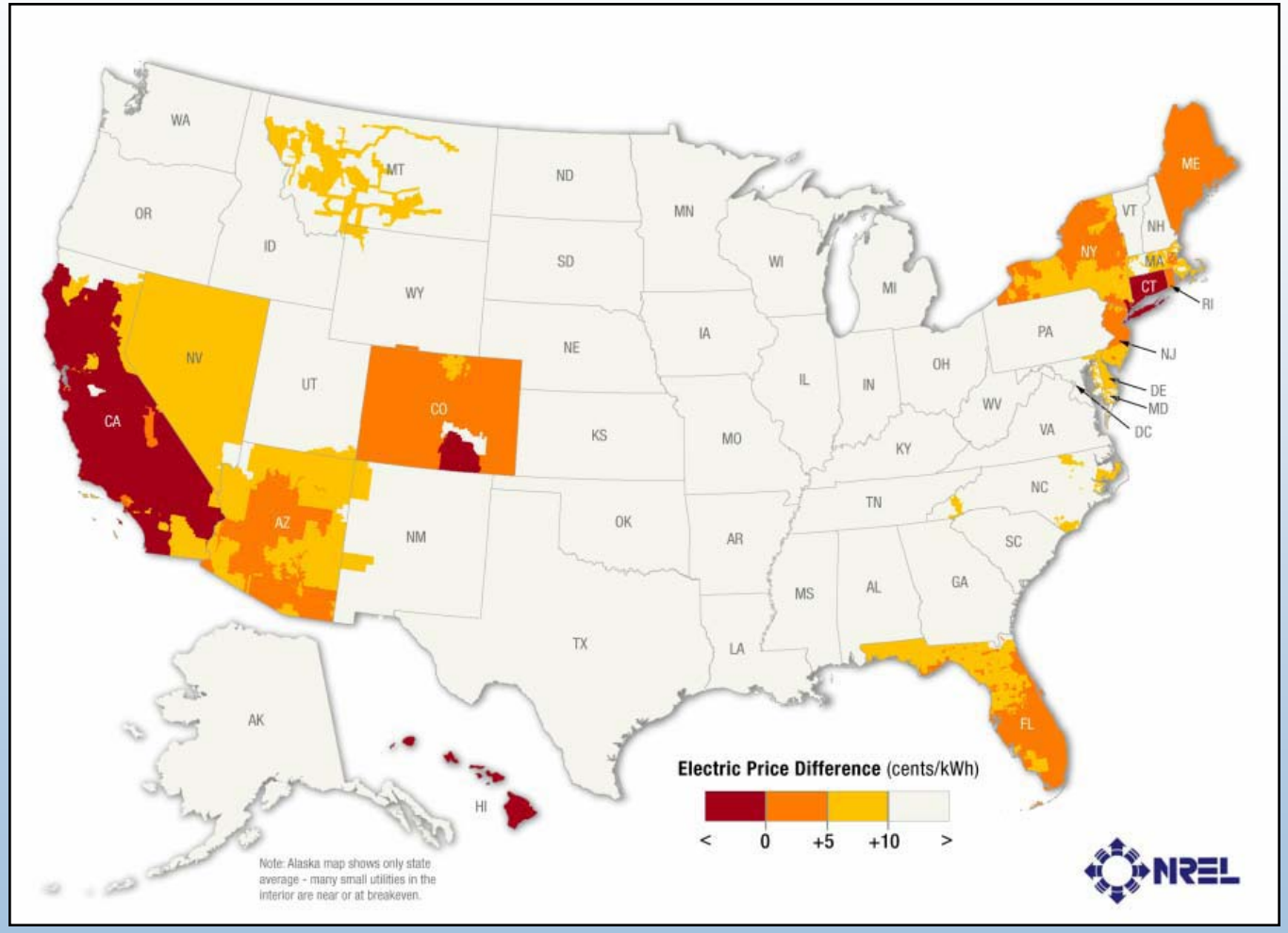
- Reducing cost
- Improving performance and reliability
- Maintaining balance between supply and demand (polysilicon supply, manufacturing capacity, distribution/ installation networks)
- Understanding and acceptance by financial sector, regulators, utilities
- Integrating solar with other systems (grid,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

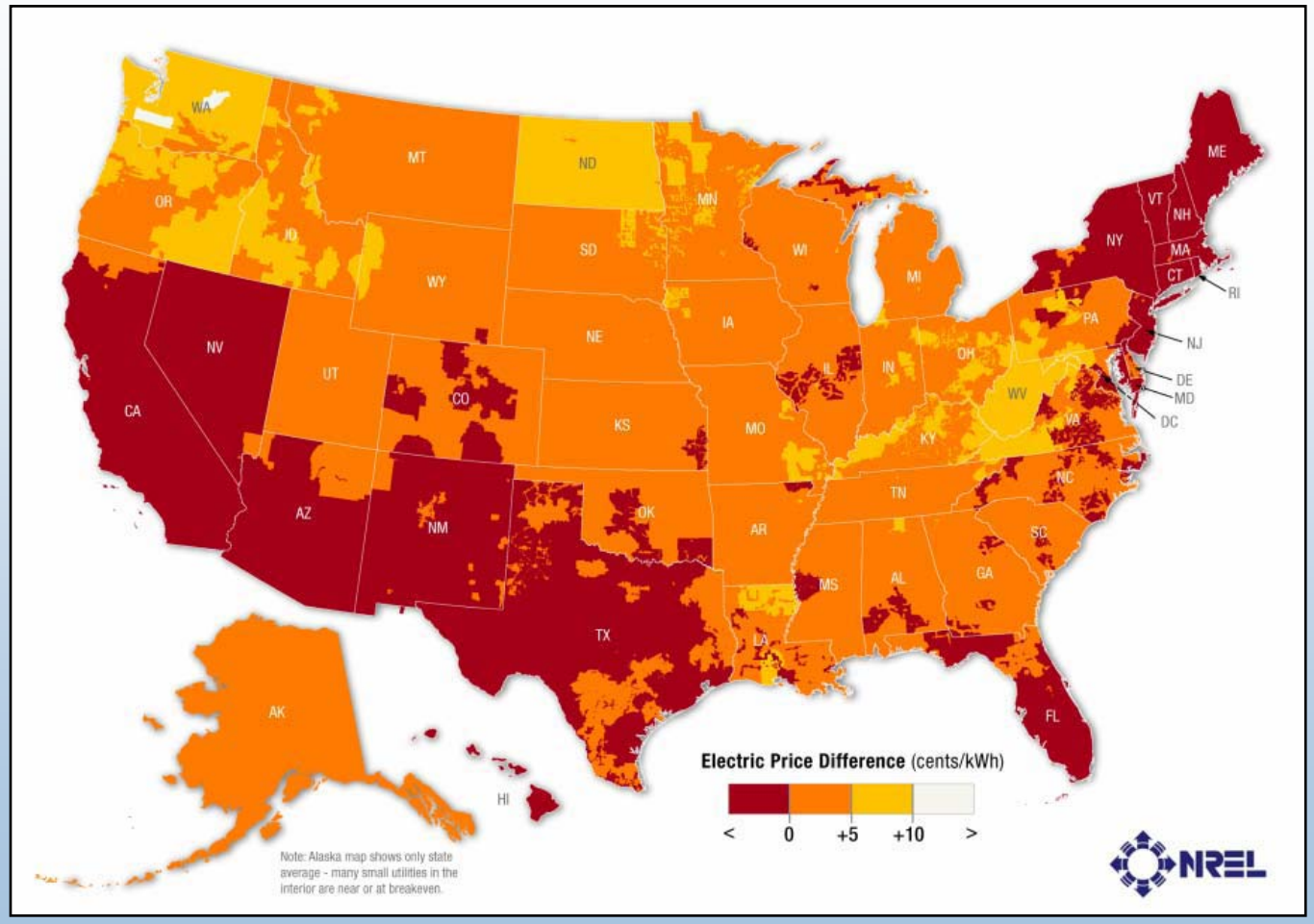
2007 residential PV and electricity price differences with existing incentives

- Analysis for 1000 largest utilities in the U.S.
- Currently PV is only attractive where there is a combination of high electricity prices and incentives.



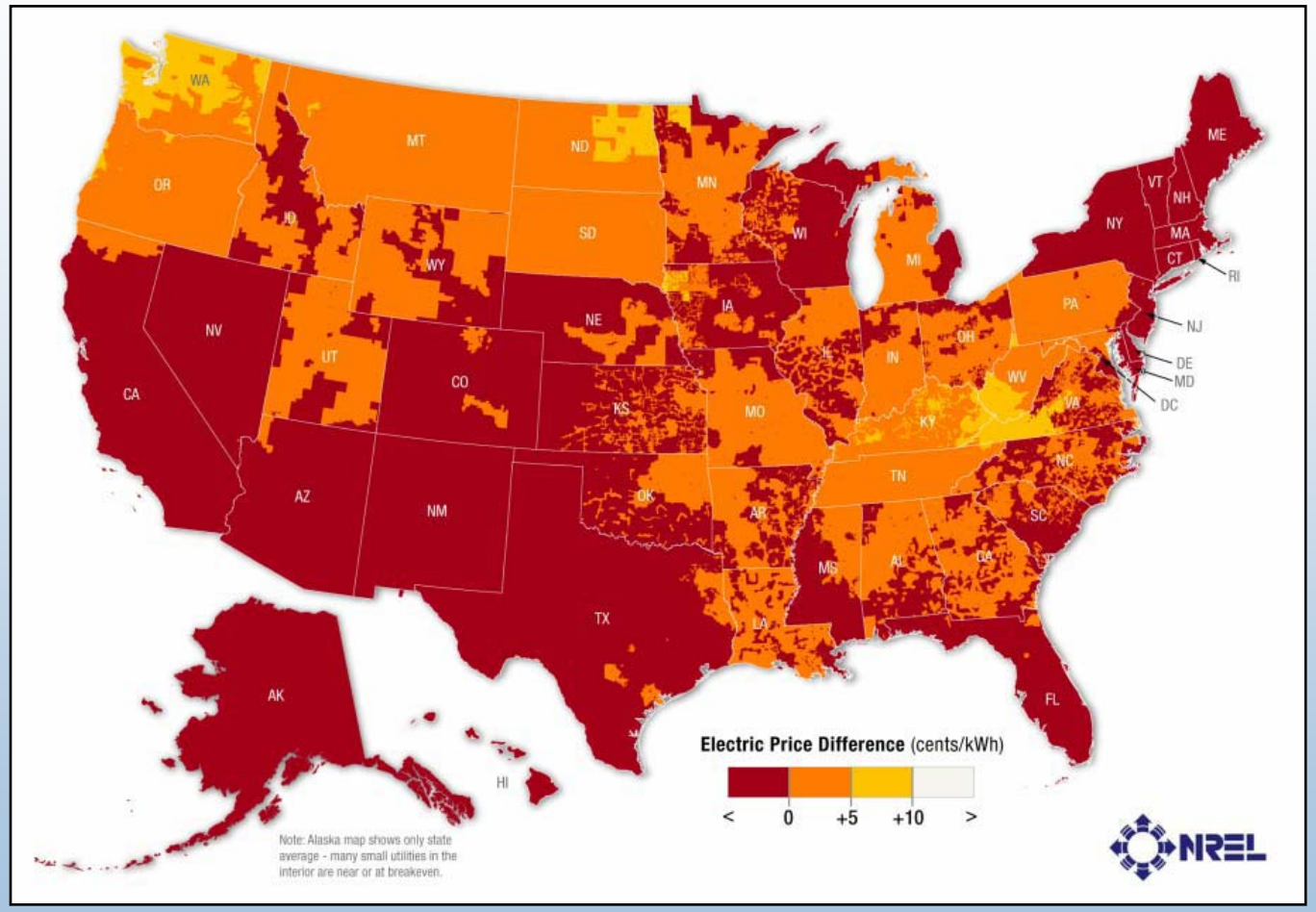
2015 residential without incentives and moderate increase in electricity prices

- 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.



2015 residential 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) are projected to have a price difference of less than 5 ¢/kWh.



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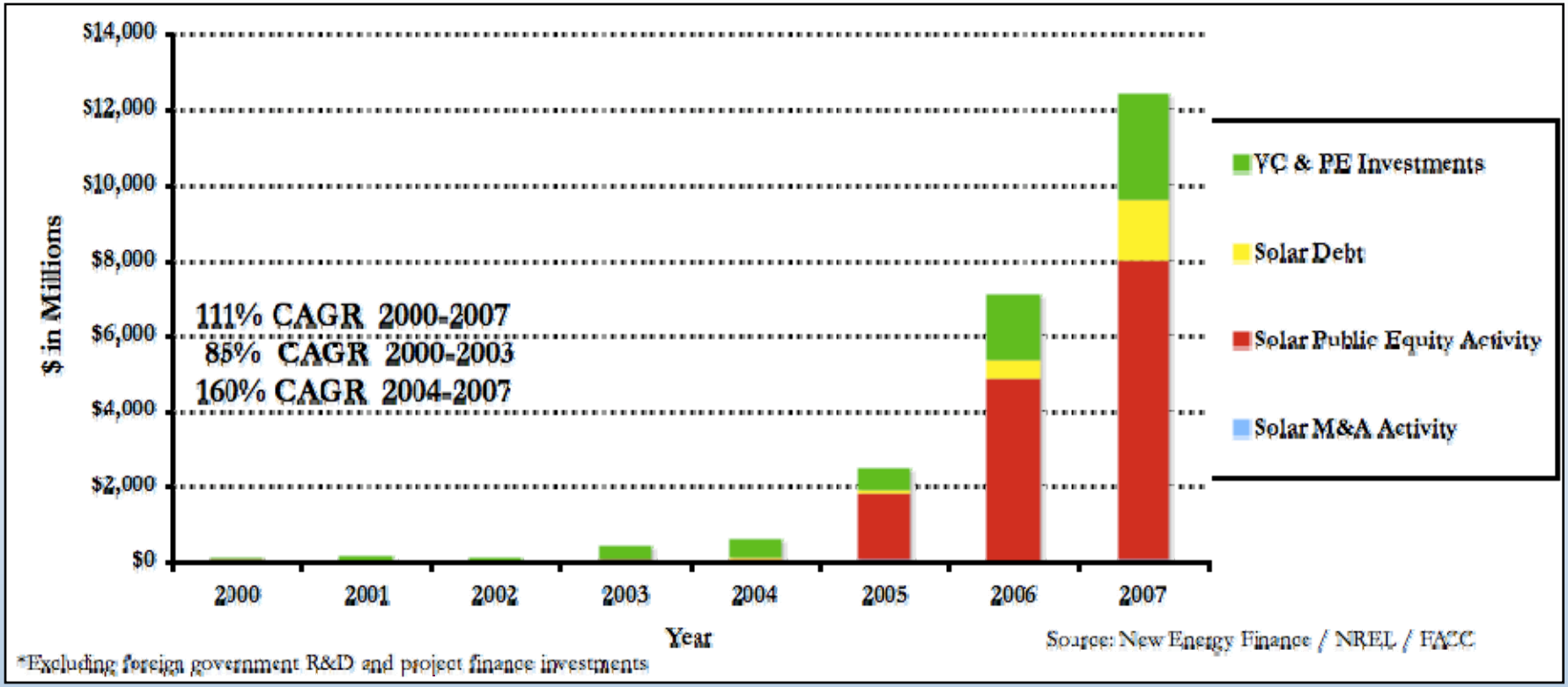
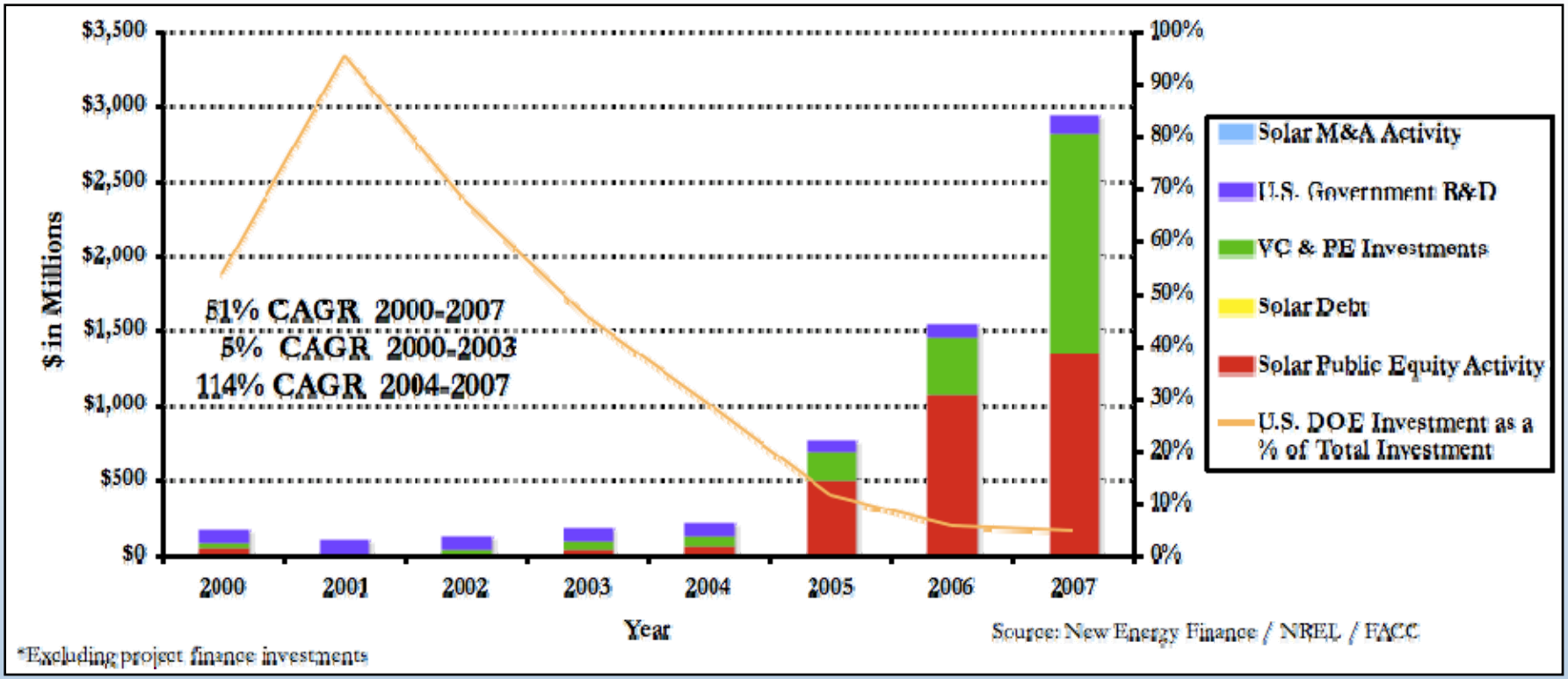
- Where do we go from here?
  - Changing role for public and private sectors?

Total global investment in solar energy



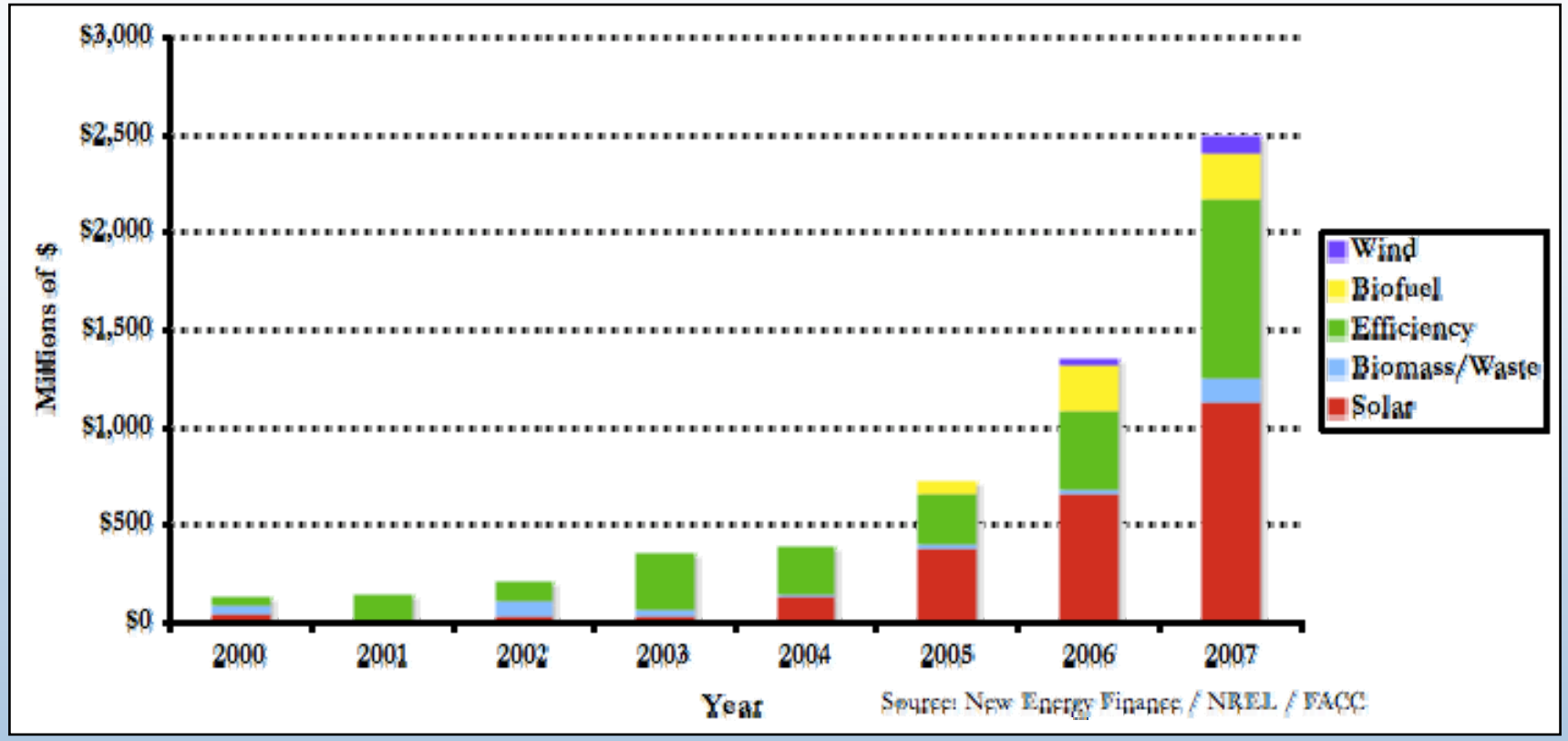
- Total global investment in solar increased from $66M in 2000 to $12,387M in 2007, representing a 111% CAGR.
- Investment accelerated over the past three years as public equity offerings became an even larger source of capital.

Total U.S. investment in solar energy



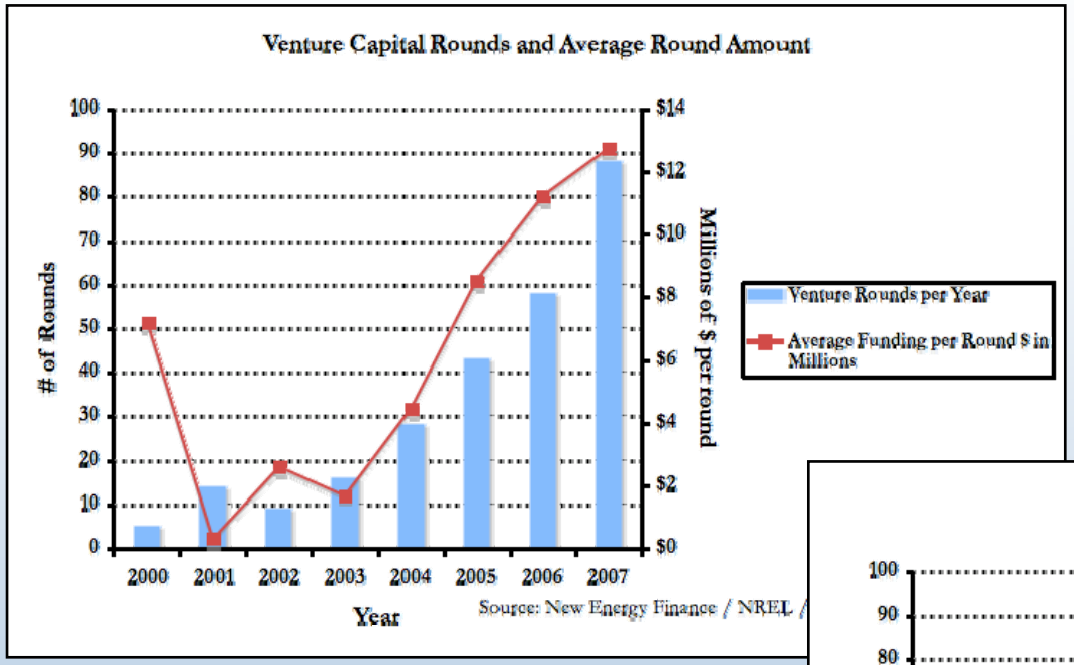
- U.S. DOE funding of solar technologies dropped from 53% of total investment in 2000, to 4% of the total amount invested in U.S. companies in 2007.

Global venture capital funding by clean energy technology

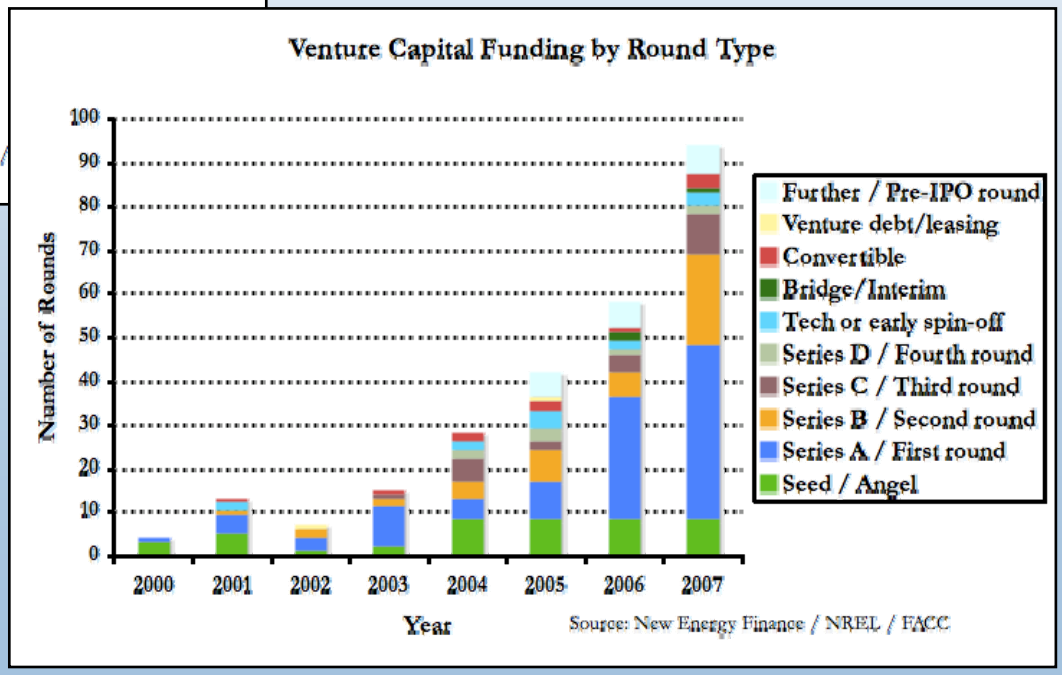


- Solar and energy efficiency technologies have received the lions share of venture investment.

Global solar venture capital trends

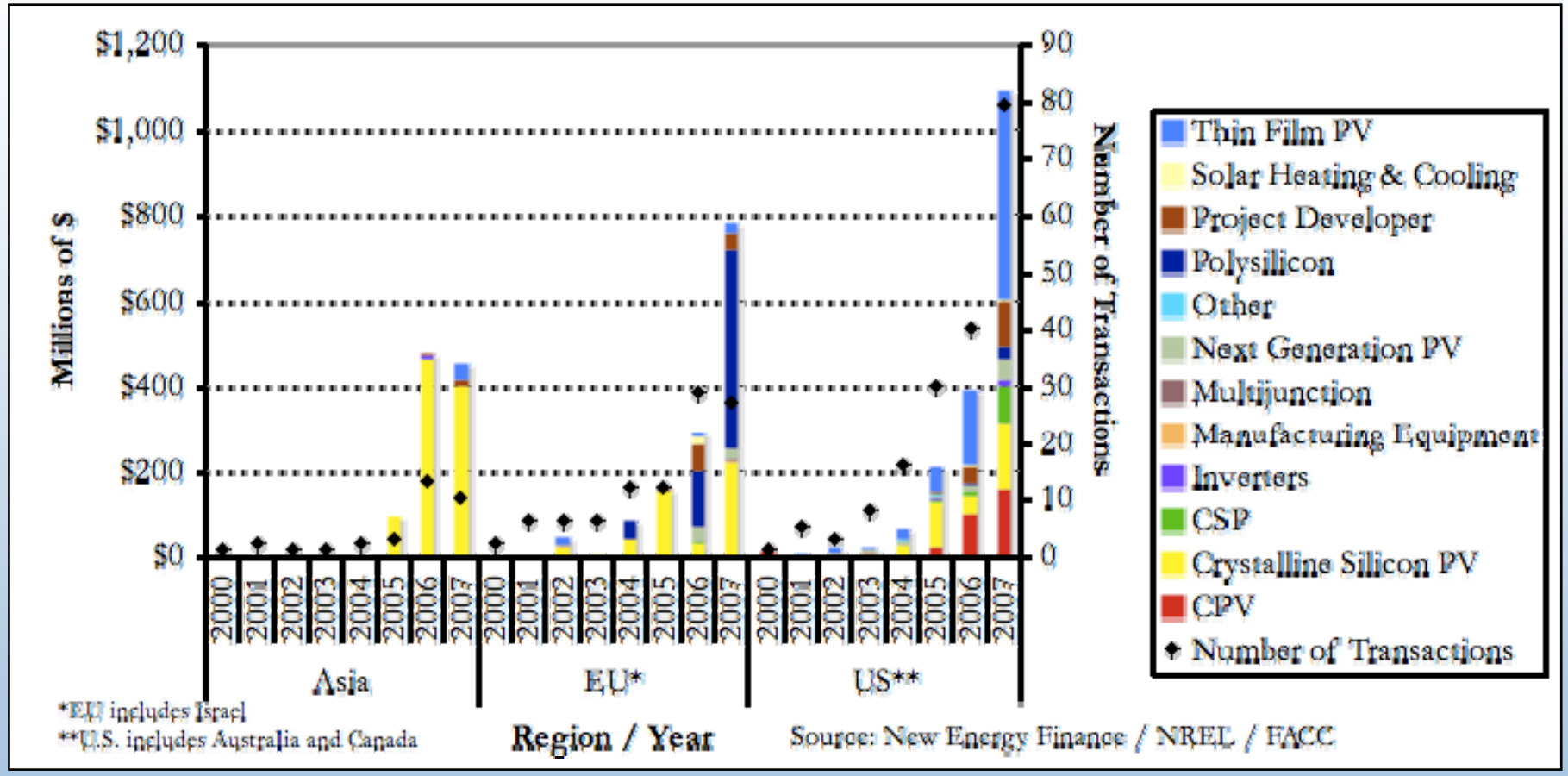


- Venture deal volume and average round amount have increased substantially…



- While, early round activity has continued to accelerate, indicating that the market for innovation has not been saturated.

Global private investment in solar by region and technology



- U.S. investors are pursuing a more diverse set of technologies than investors in other regions.

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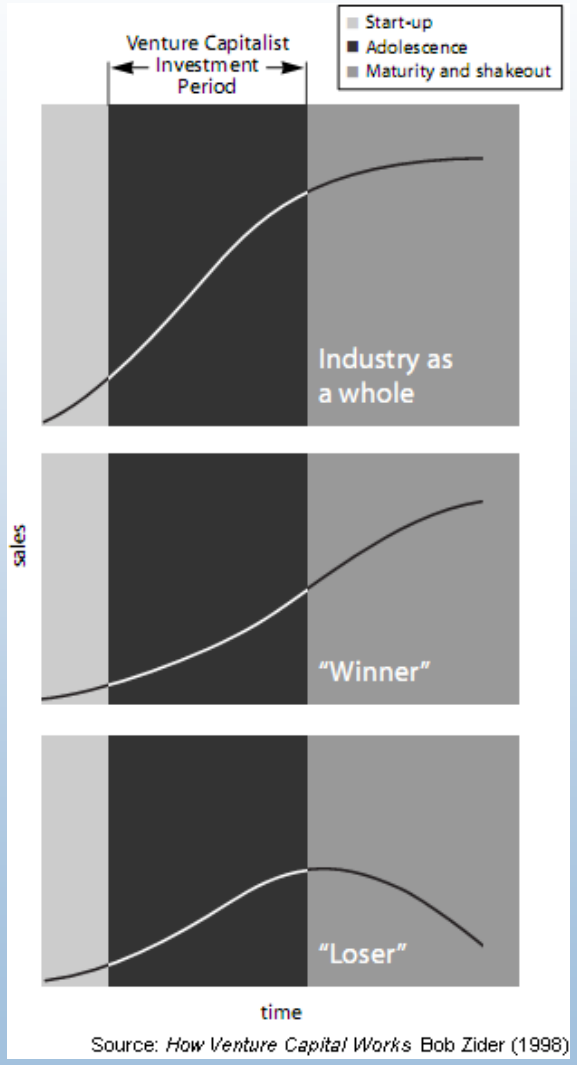
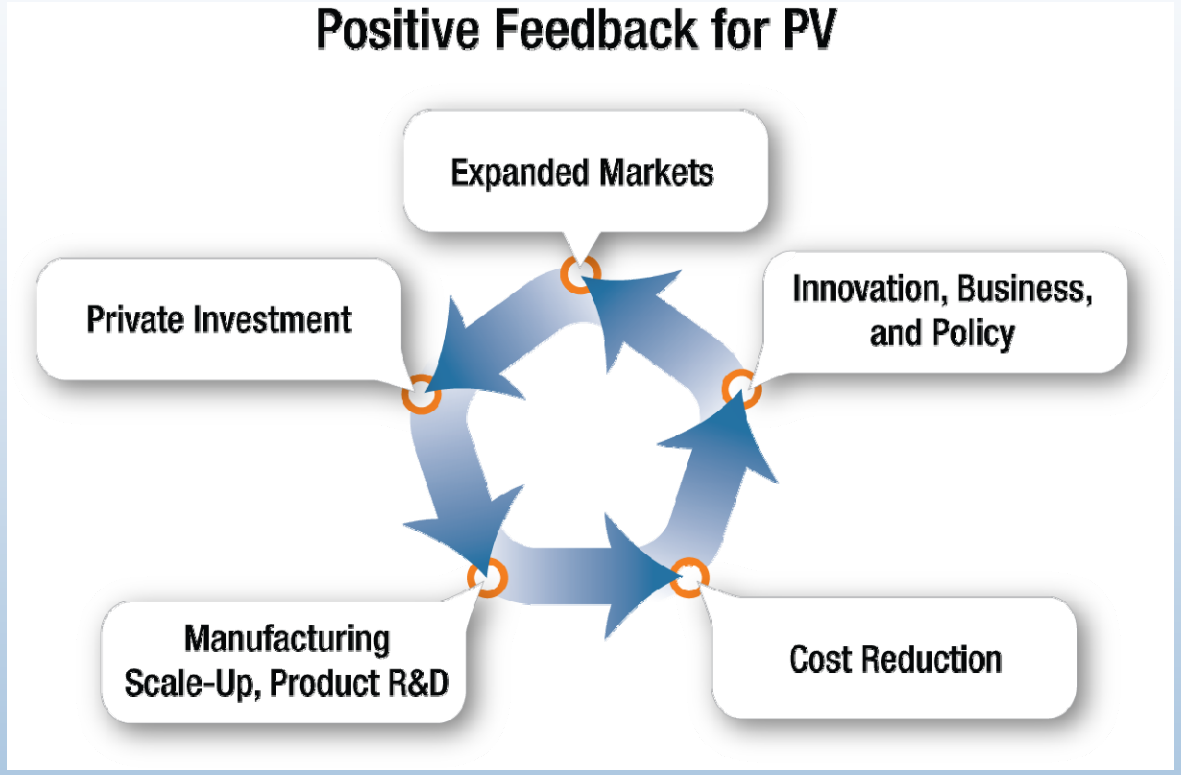
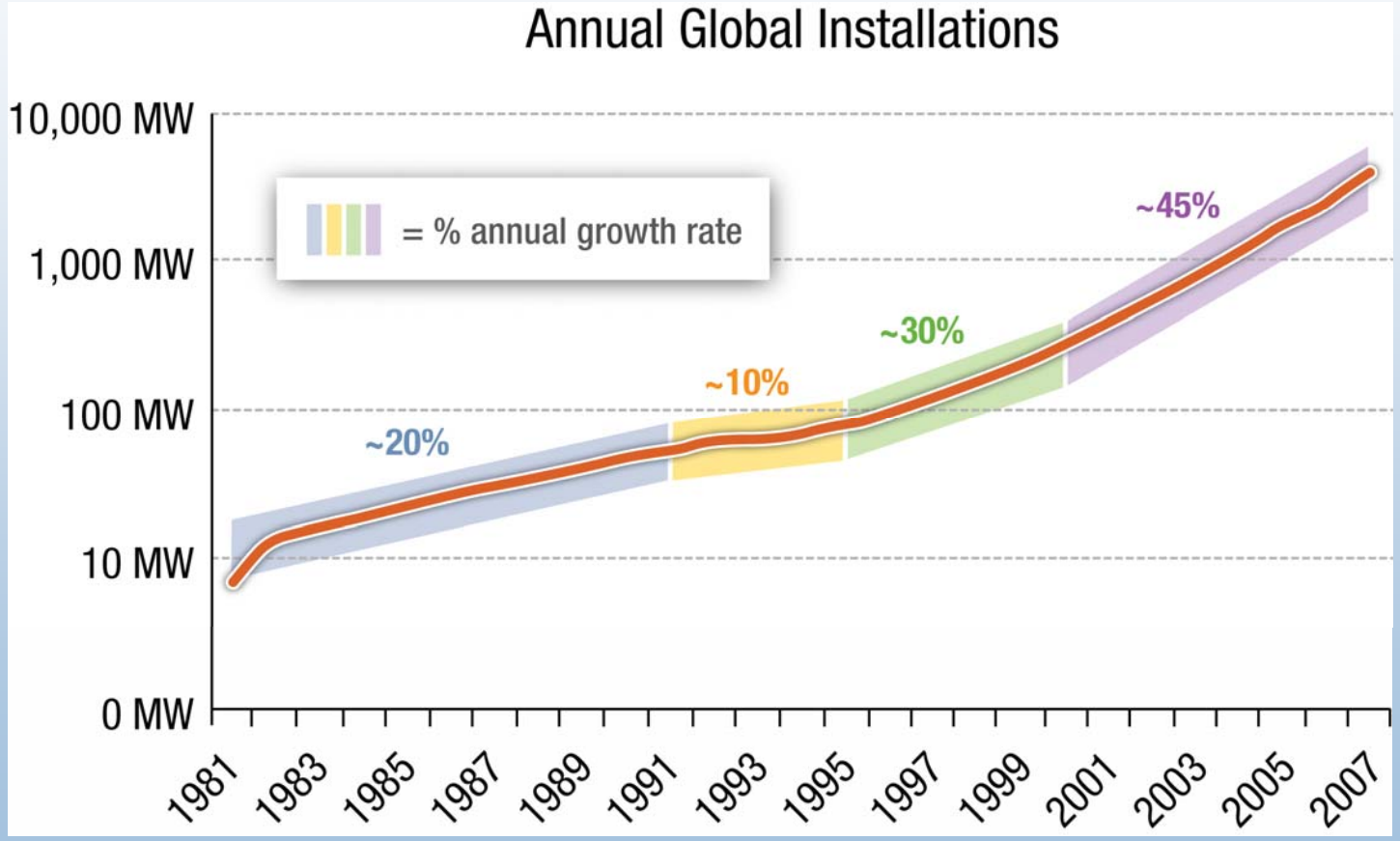
  - Changing dynamics in the market place.

Solar's inflection point is still well off

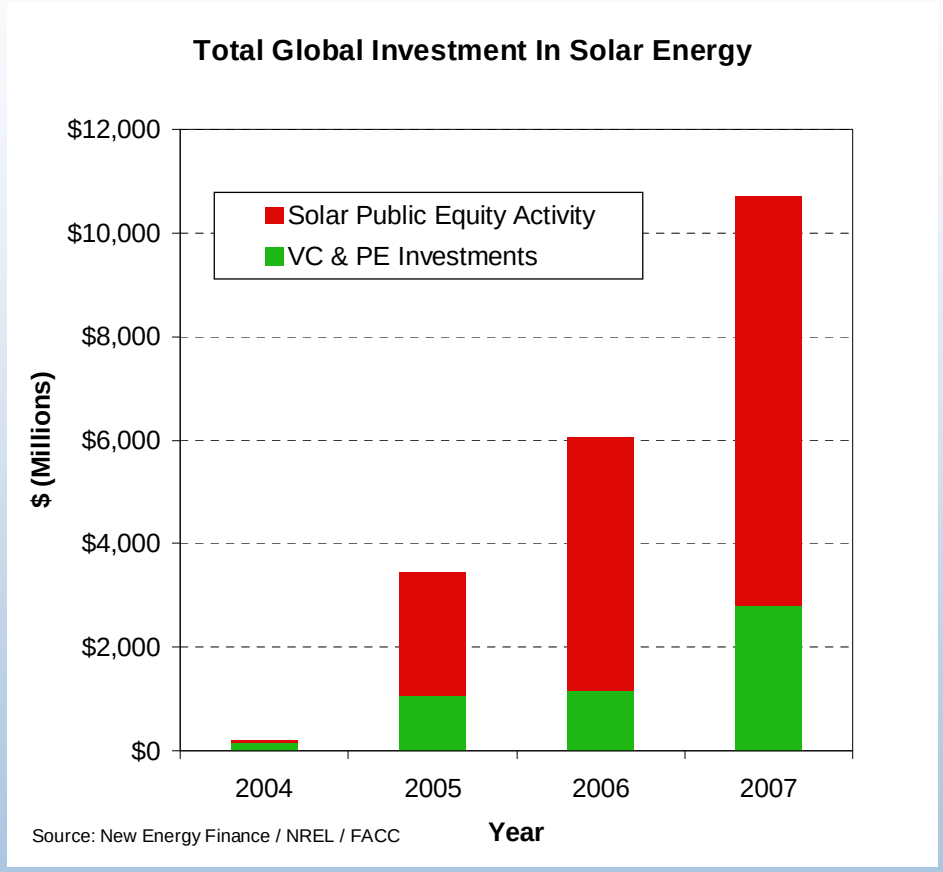


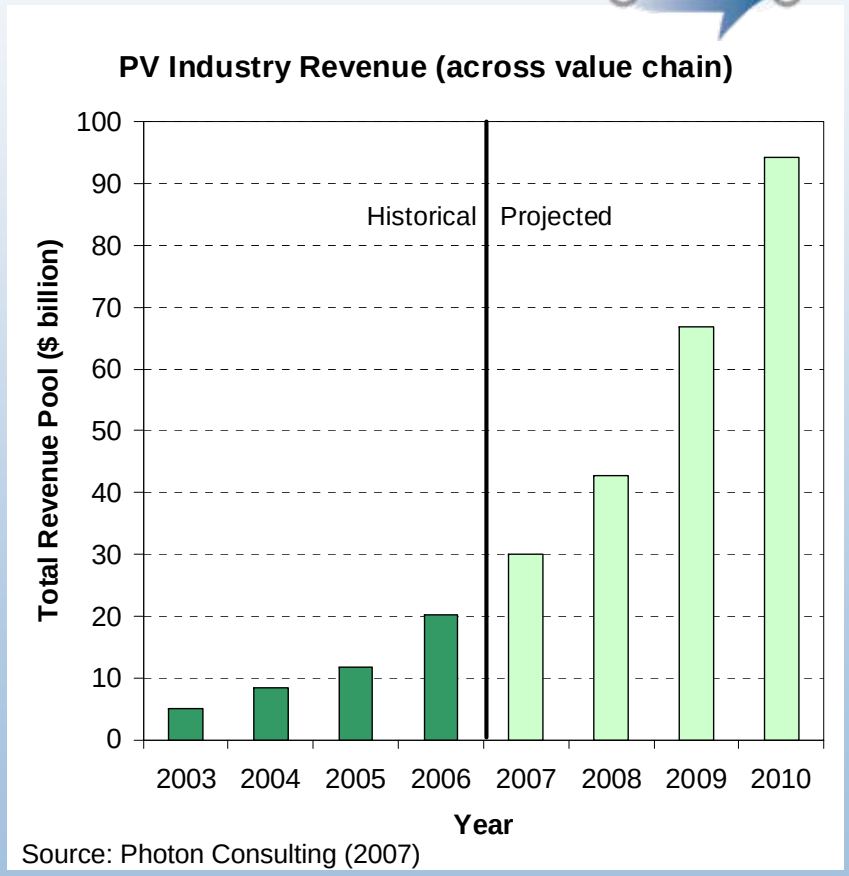


Market demand has produced super exponential growth

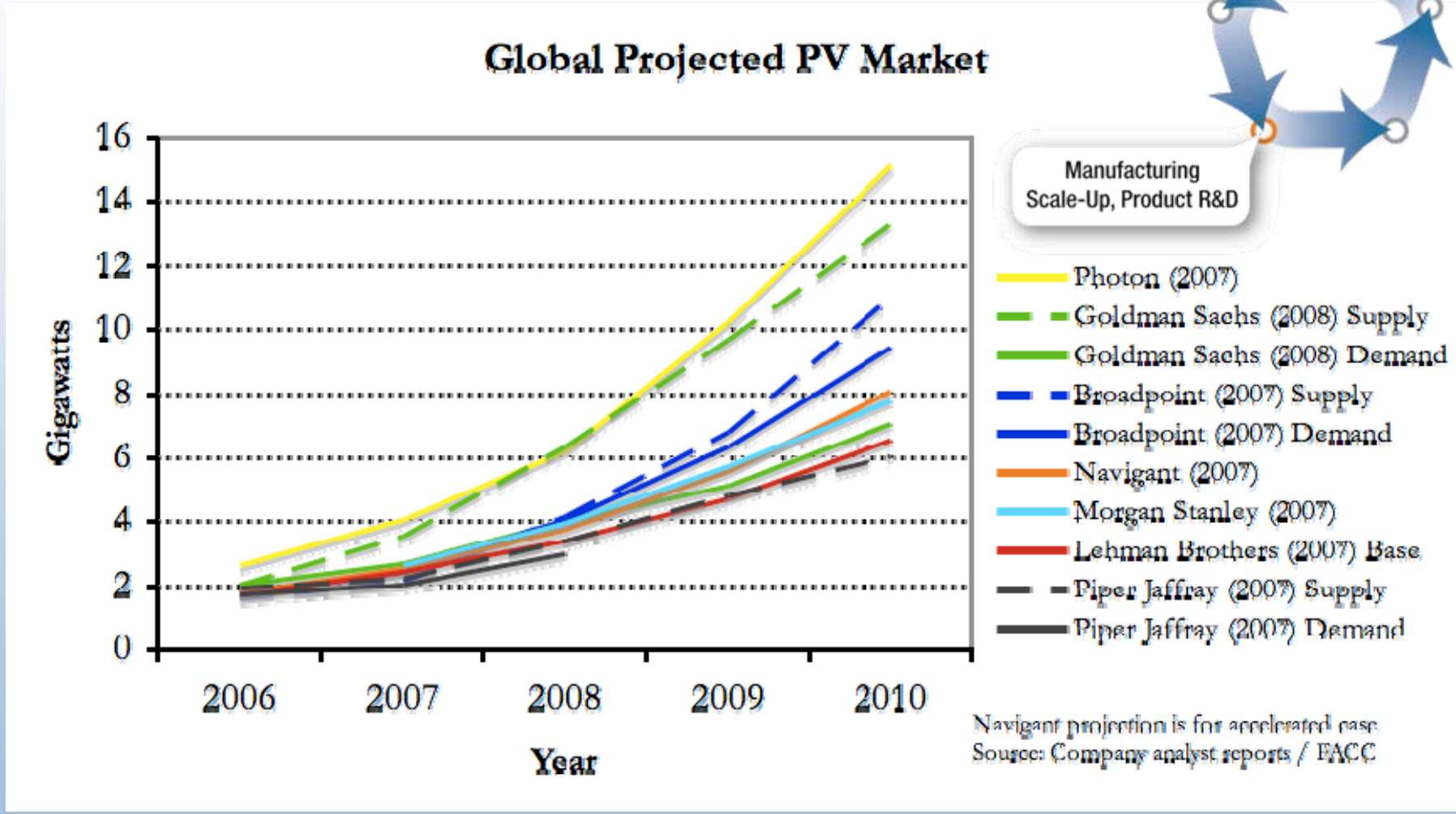


Which has stimulated investment in the solar sector

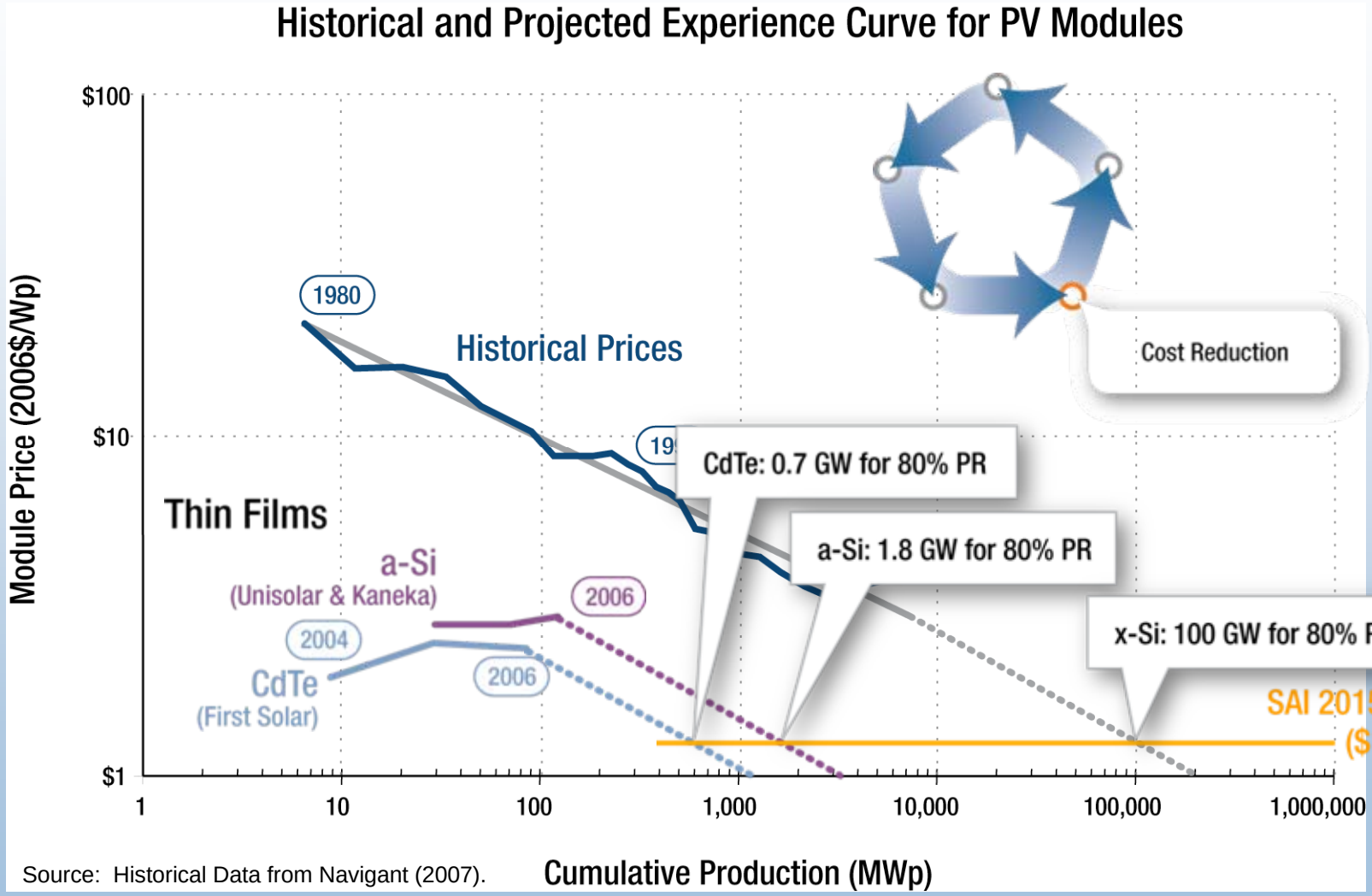




Leading to manufacturing scale-up, and…

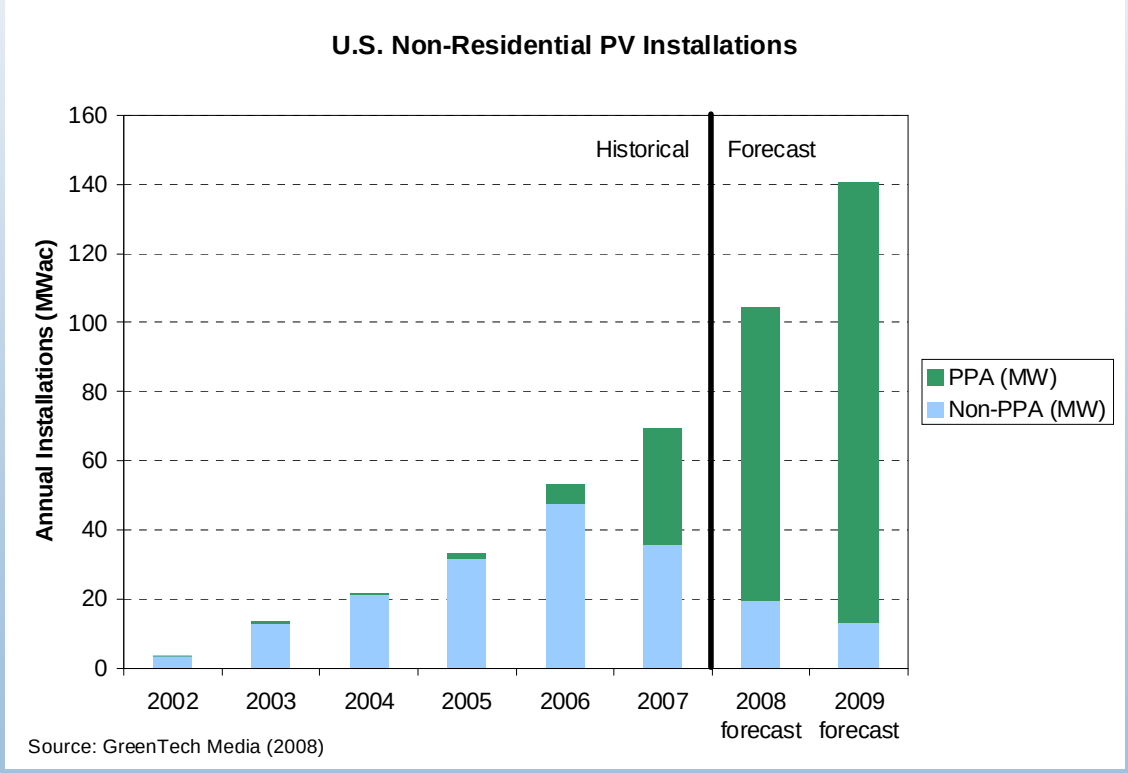


… associated cost reductions



Source: Historical Data from Navigant (2007).

Driving innovation in business models and government policy



Concept:

- Power Purchase Agreements (PPA)
- Feed-In-Tariffs (with solar carve out)
- Investment and residential tax credits
- REC / Carbon Policy
- Creative Funding Vehicles

Implementation:

- Federal Installations
- LEED / E-Rating
- Clean Renewable Energy Bond
- Property Tax Assessment (no double dipping with ITC)

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

- Federal, state, and local policy incentives.
- Market volatility and high cost of 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”.

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Some possible suggestions

- Supply-chain development
- Grid integration
- Expanded CSP initiative
- Pre-incubator
- Workforce development
- Other?
  - Expand: incubator, testing and evaluation, resource assessment, Solar America Cities
  - New: storage, transmission, university research centers (with BES?)

Supply-chain development (1): Maturation of the domestic solar manufacturing industry

- **Activity Description:** Establish and optimize manufacturing processes and develop necessary equipment to increase domestic solar component and system production capacity.
- **R&D Areas:**
  - Strategic investments in critical materials supply.
  - High-volume process machinery.
  - Standard diagnostics.
  - Standard installation practice.
  - Product reliability and disposal infrastructure.

Supply-chain development (2): Avoiding shortages of critical materials

- **Activity Description:** Work on upstream and crosscutting product and process development to avoid future bottlenecks during industry scale-up.
- **R&D Areas:**
  - Develop and improve alternative low cost polysilicon production processes.
  - New upstream and crosscutting R&D aimed ensuring a clear path towards future cost reductions, e.g., glass, flexible encapsulants, films, substrates, etc.

Grid integration: Renewable Systems Interconnection

- **Activity Description:** Address renewable energy generation intermittency by developing and demonstrating low-cost integrated control and storage technologies for all renewable generation facilities, power-plants, systems, and equipment, including PV.
- **R&D Areas:**
  - Distributed PV System Technology Development
  - Advanced Distribution Systems
  - System Level Test and Demonstration
  - Distributed Renewable Energy System Analysis
  - Solar Resource Assessment
  - Codes, Standards, and Regulatory Implementation

Expanded CSP initiative

- **Activity Description:** Establish activities to enable CSP to become competitive as a baseload power source, i.e., with adequate storage, by 2020.
- **R&D Areas:**
  - Investigate storage materials capable of operation above 500°C.
  - Develop highly efficient thermal storage systems, i.e, with efficiencies above 93%.
  - Expand R&D on wider range of CSP technologies (e.g. power tower, linear Fresnel, etc.).
  - Develop cost effective "dry cooling" technologies to minimize power plant water use in desert climates
  - Develop manufacturing techniques to enable scale-up and low-cost deployment.

Pre-incubator: SAI PV R&D Evolution

- **Activity Description:** Research and development to move from a concept or lab demonstrated process of a device or module to a prototype. Address the barriers to the prototype entry, with emphasis on commercialization further down the road.
- **R&D Areas:**
  - Novel wafer-based silicon modules
  - Polycrystalline thin films
  - Film silicon on a foreign substrate
  - High-efficiency cells, including multi-junction, and CPV module concepts
  - Organic PV, DSSC's, or other polymer-based solar cells
  - Low-X concentration CPV systems

Workforce development: Human capital development program

- **Activity Description:** Address the emerging human capital shortage in the solar industry by cultivating a strong solar labor pool with training and ideas at the cutting edge of research, development and industrial deployment.
- **R&D Areas:**
  - Provide graduate assistanceships, post-doctoral fellowships, and support for scientists changing careers into solar to train in U.S. national labs, universities, and industry.
  - Fund federal grants for university and community college course sequences and “hands-on” research and training apprenticeships.