



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



Solar Energy Technologies Program

National Institute of Standards and Technology High-MW Electronics Seminar

“Investments in Power Electronics within the Solar Energy Technologies Program”

John M. Lushetsky

Program Manager

Solar Energy Technologies Program (SETP)

Department of Energy

Office of Energy Efficiency and Renewable Energy

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Excitement, Leadership, and Opportunity



President Barack Obama

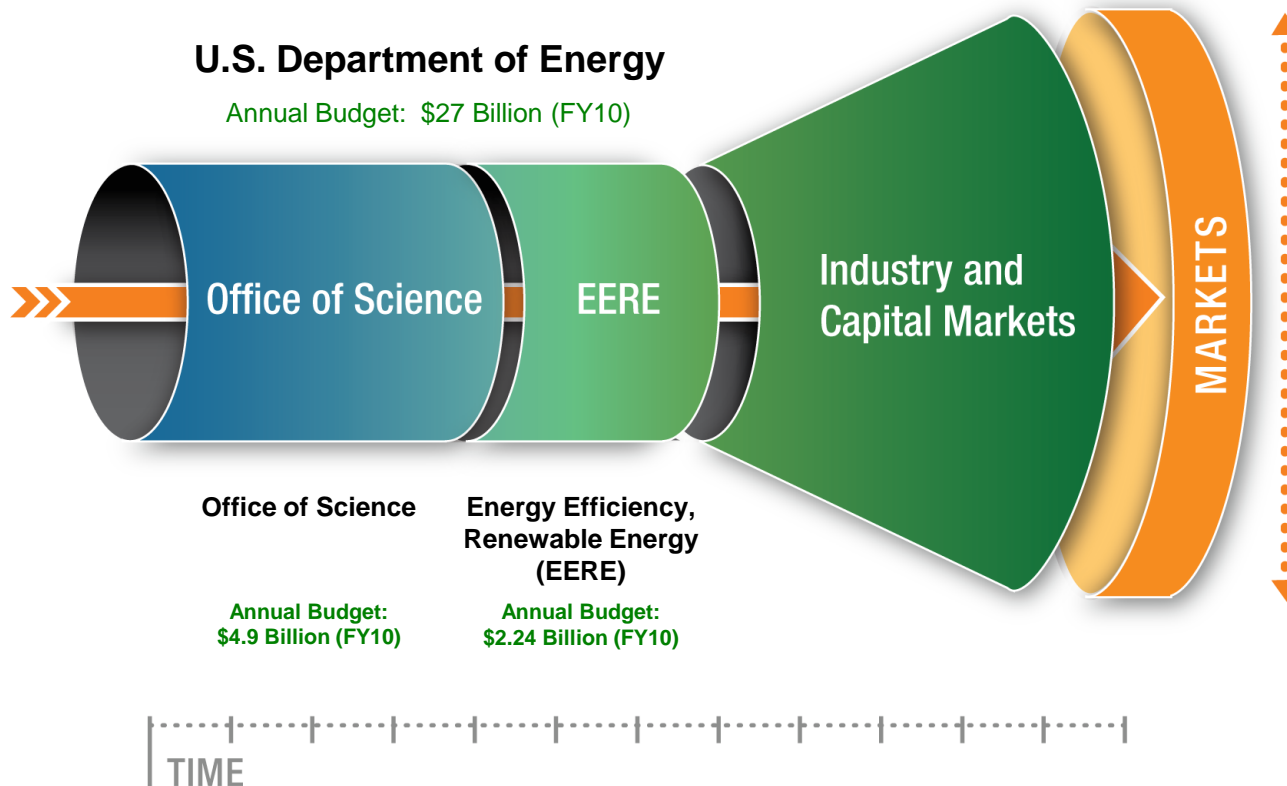
**President Obama's Swearing-In Ceremony
January 20, 2009**

**Dr Steven Chu, Secretary of Energy
Nobel Laureate, Ph.D. Physics,
Former Director of LBNL**

“We will harness the sun and the winds and the soil to fuel our cars and run our factories...All this we can do. All this we will do.”

President Obama, January 20, 2009

DOE programs address the technology innovation and capital needs across the development pipeline



Electric Power Generation

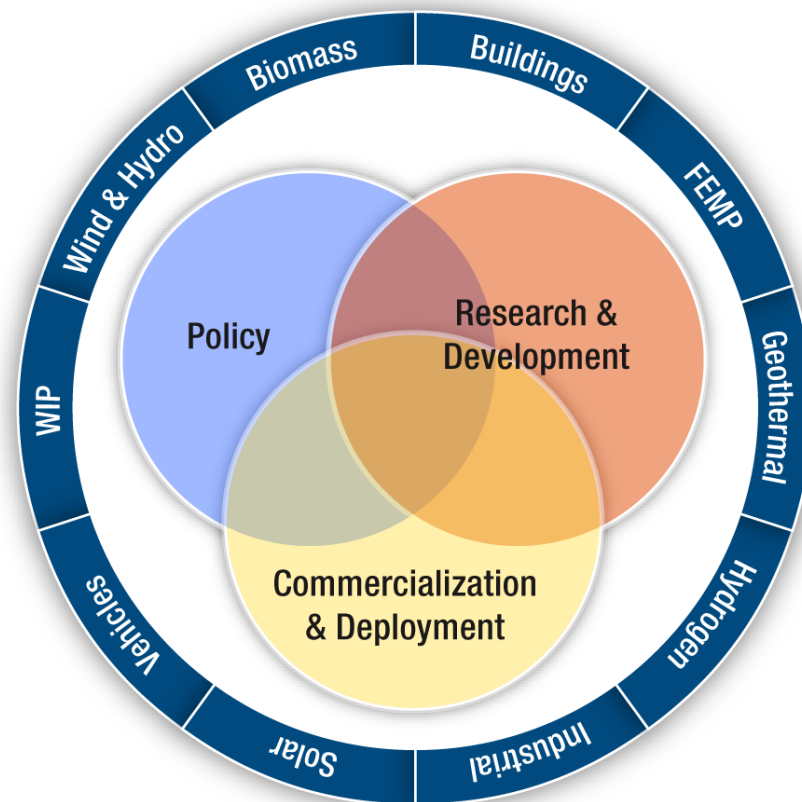
- Geothermal
- Solar
- Wind & Hydropower

Advanced Transportation

- Biomass
- Fuel Cells
- Vehicles

Energy Efficiency

- Buildings
- Industrial
- Federal Energy Management
- Weatherization and Intergovernmental



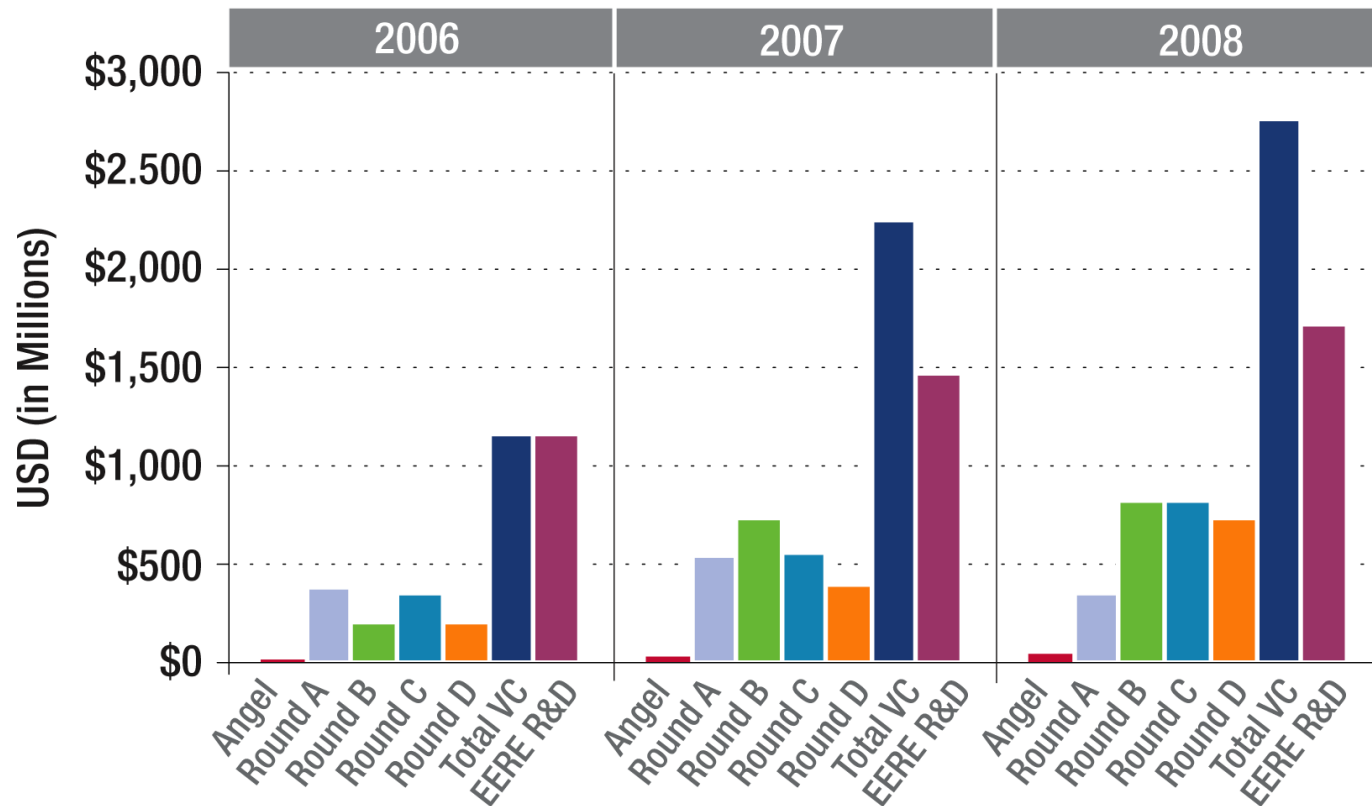
MISSION STATEMENT

Develop cost competitive clean energy technologies and practices and facilitate their commercialization and deployment in the marketplace to strengthen America's energy security, environmental quality, and economic vitality.

Investment in the US Cleantech industry over the past three years

DOE's Office of Energy Efficiency and Renewable Energy accounts for almost 40% of early-stage cleantech funding

VC and EERE Investments in U.S. Cleantech

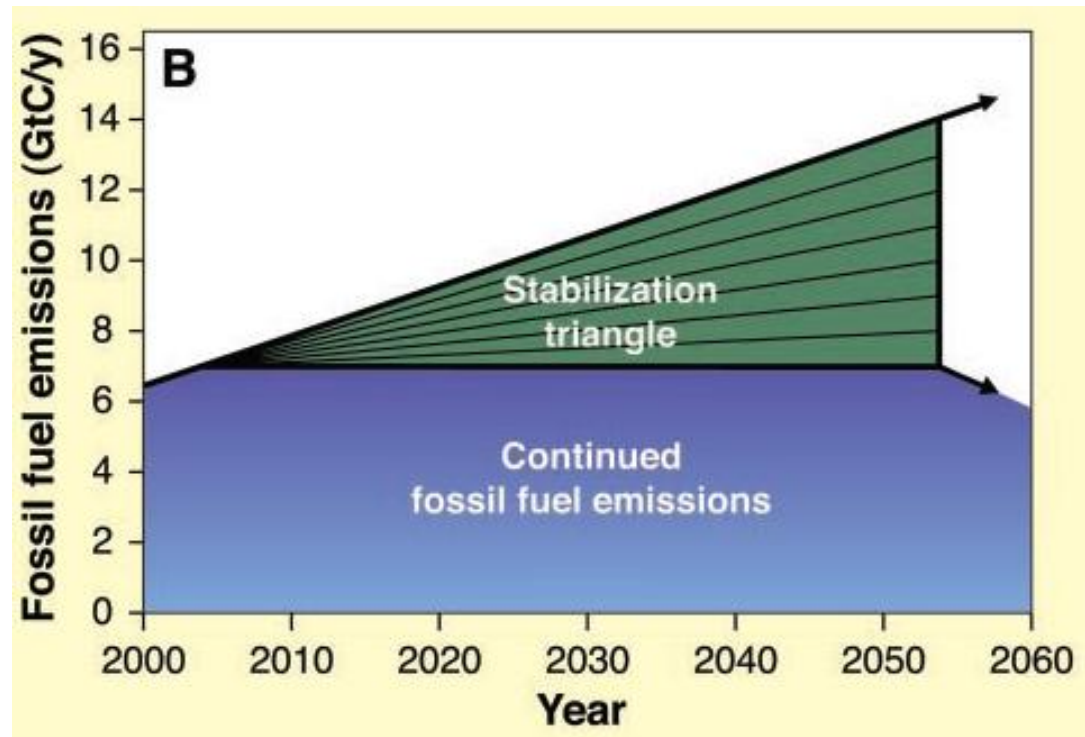


Sources:
DOE and New
Energy Finance

Scale of the challenge to address climate change

- Increase fuel economy of 2 billion cars from 30 to 60 mpg.
- Cut carbon emissions from buildings by one-fourth by 2050—on top of projected improvements.
- With today's coal power output doubled, operate it at 60% instead of 40% efficiency (compared with 32% today).
- Introduce Carbon Capture and Storage at 800 GW of coal-fired power.
- Install 1 million 2-MW wind turbines.
- Install 3000 GW-peak of Solar power.
- Apply conservation tillage to all cropland (10X today).
- Install 700 GW of nuclear power.

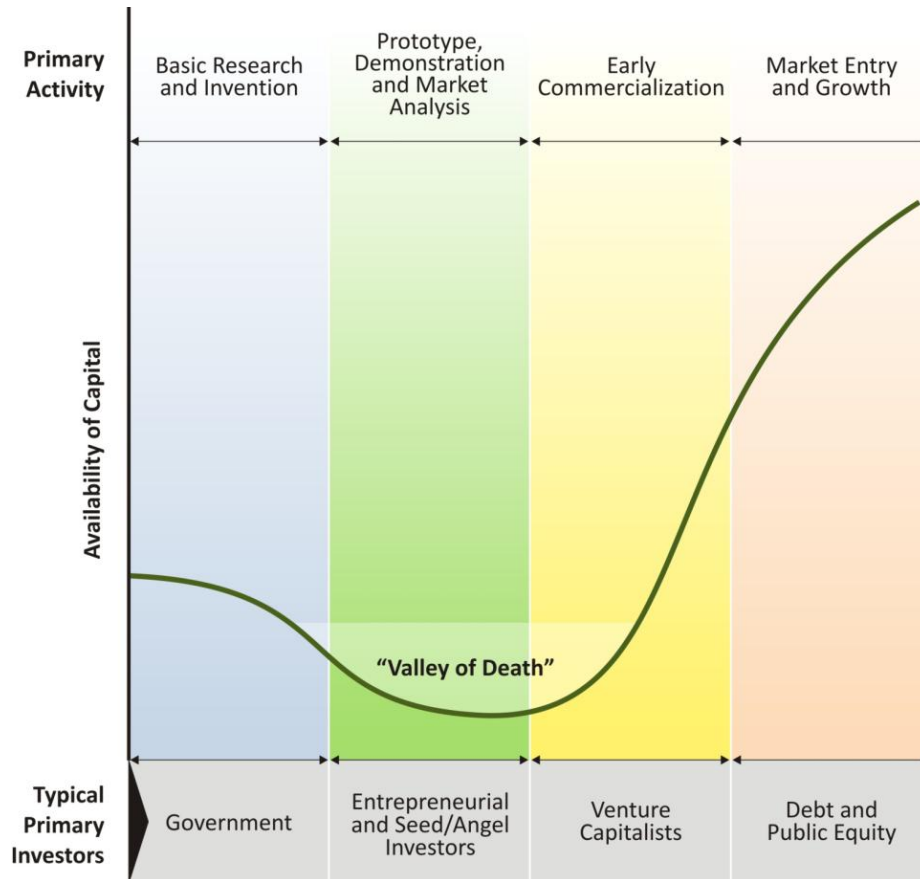
Source: S. Pacala and R. Socolow, "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technology", *Science* 13 August 2004, pp.968-972.



Time Constants for Change

- **Political consensus building** ~ 3-30+ years
- **Technical R&D** ~10+
- **Production model** ~ 4+
- **Financial** ~ 2++
- **Market penetration** ~10++
- **Capital stock turnover**
 - Cars ~ 15
 - Appliances ~ 10-20
 - Industrial Equipment ~ 10-30/40+
 - Power plants ~ 40+
 - Buildings ~ 80
 - Urban form ~100's
- **Lifetime of Greenhouse Gases** ~10's-1000's
- **Reversal of Land Use Change** ~100's

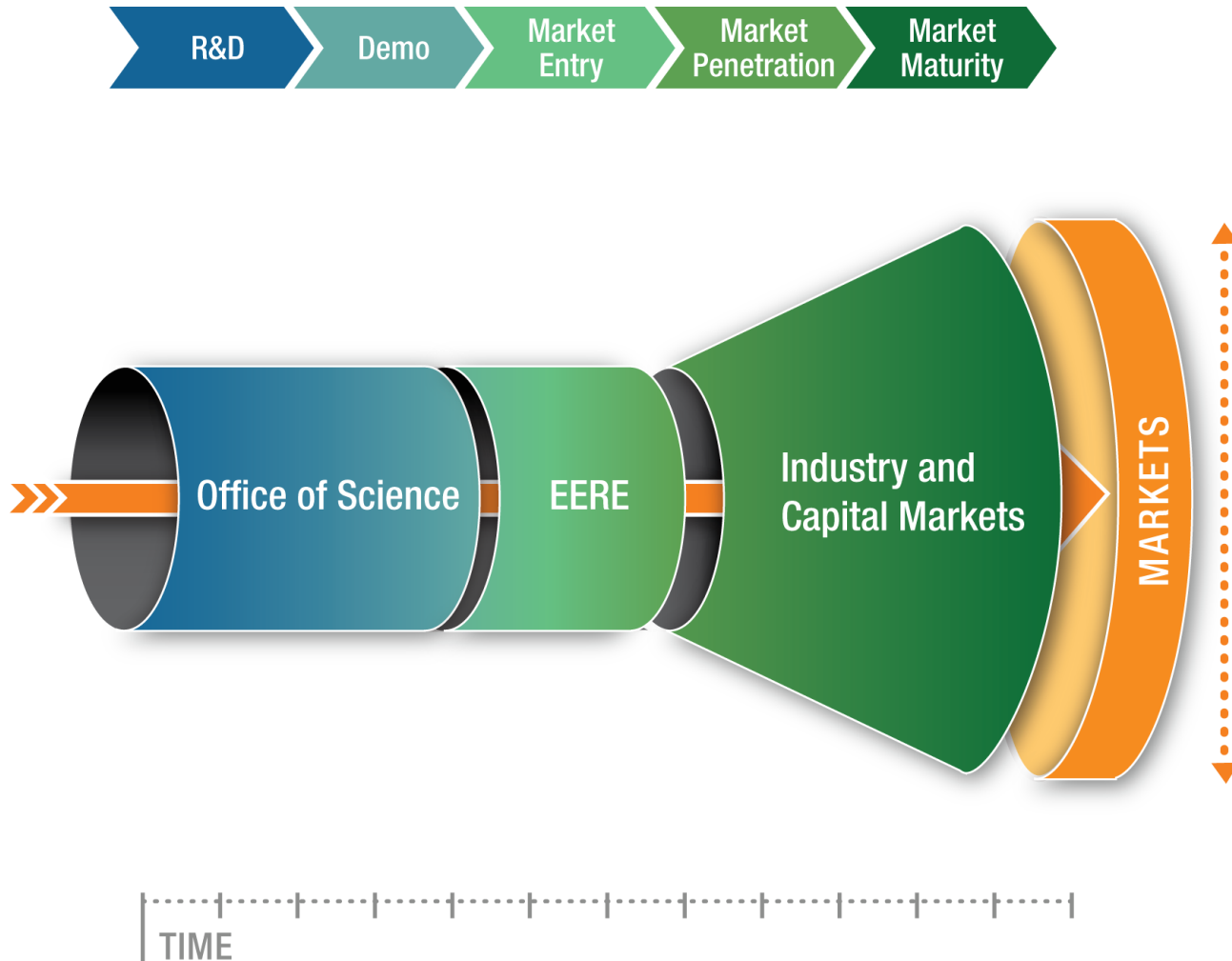
Problem for Cleantech Entrepreneurs: How to cross the “Valley of Death”



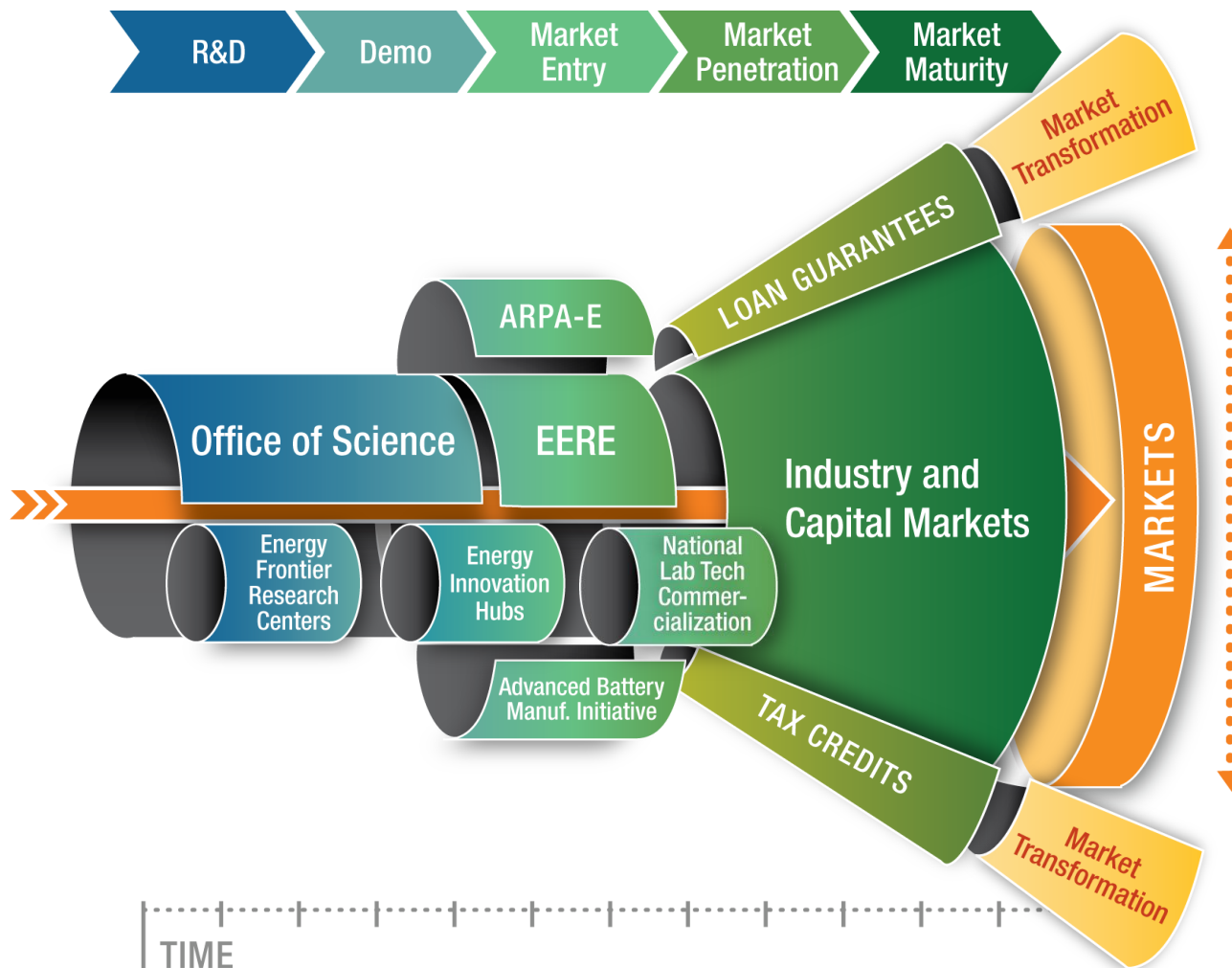
- **Significant government and university sources for Basic R&D – venture capital and public markets available for growth and expansion.**
- **Cleantech requires significant capital required for Prototype, Demonstration, and Market Validation.**
- **Cleantech is material intensive - requires higher capital levels than IT, biotech, or software.**
- **Cleantech subject to significant market risk due to government policy.**
- **Present economic and financial conditions have constrained conventional funding and “widened” the valley.**

Significant need for new and novel sources of capital and partnerships to accelerate Cleantech through commercialization

DOE programs address the technology innovation and capital needs across the development pipeline



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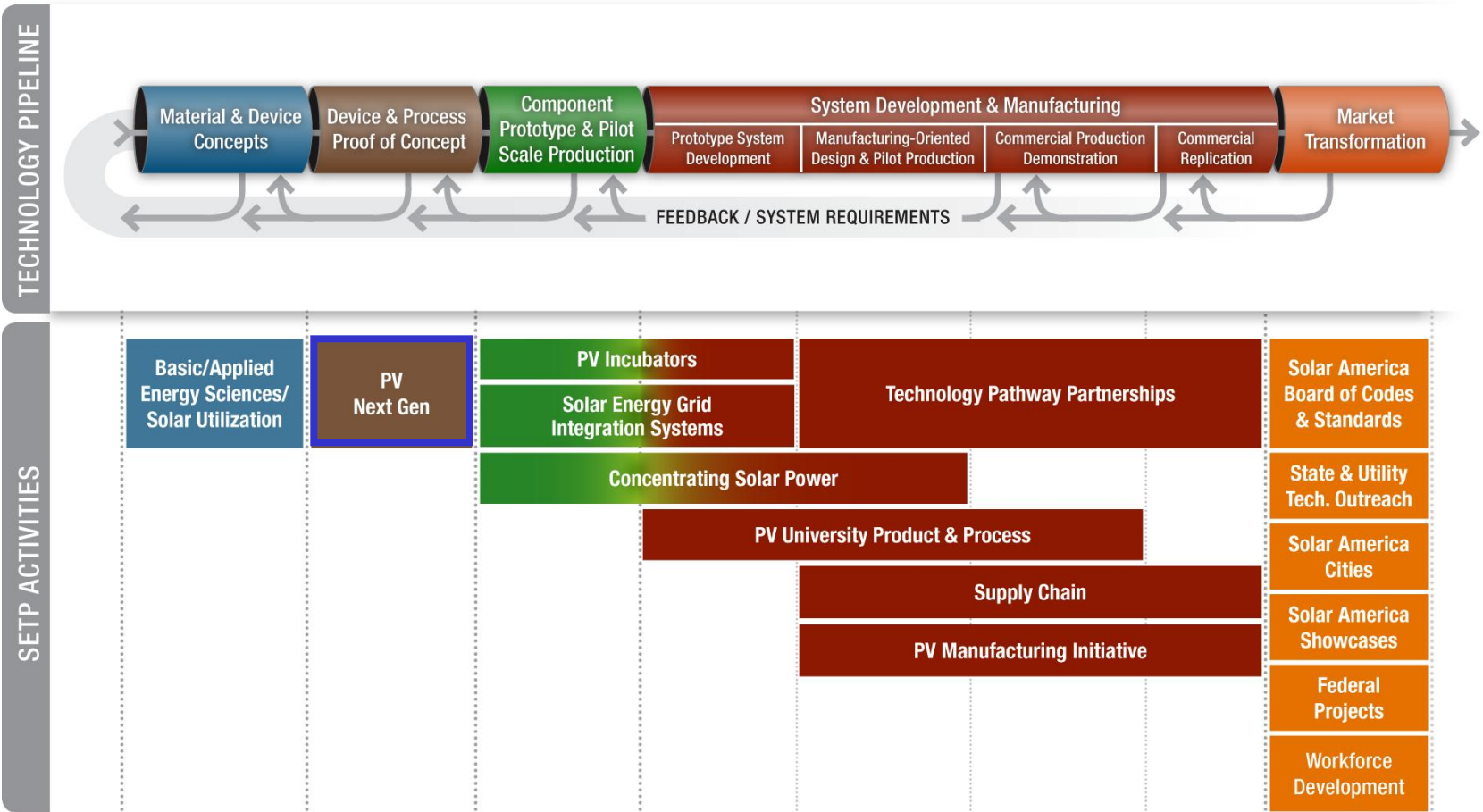
The mission of DOE's Solar Program is to accelerate the wide-spread adoption of solar electric technologies across the United States

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SETP's pipeline approach aims to balance near and long term research

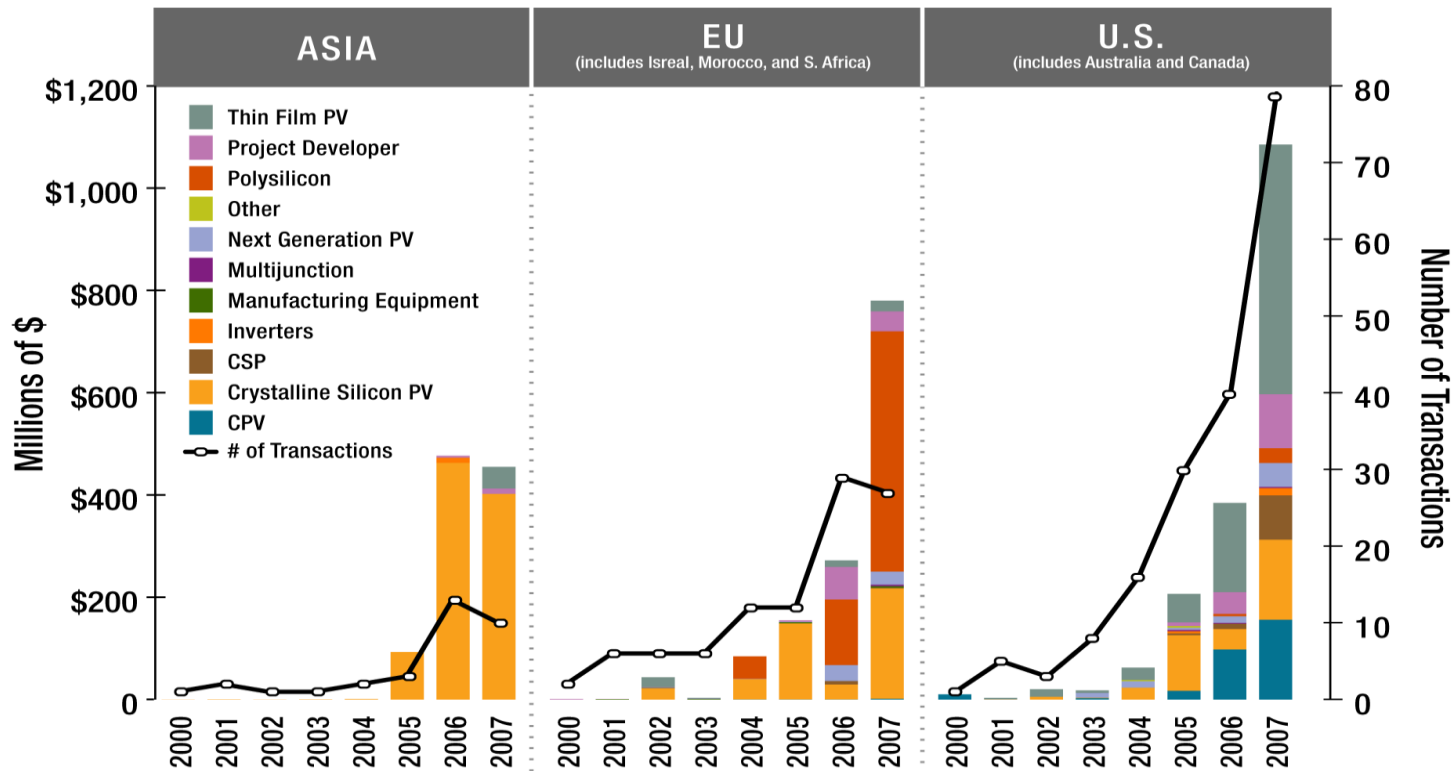


The U.S. is rich in PV technology innovation

The US is the most diversified in solar technologies receiving VC and PE financing, with substantial investment in thin film PV, as well as CPV and CSP

- In Europe, most of the funding has been to polysilicon and c-Si PV companies
- In Asia, almost all investment has gone to c-Si PV

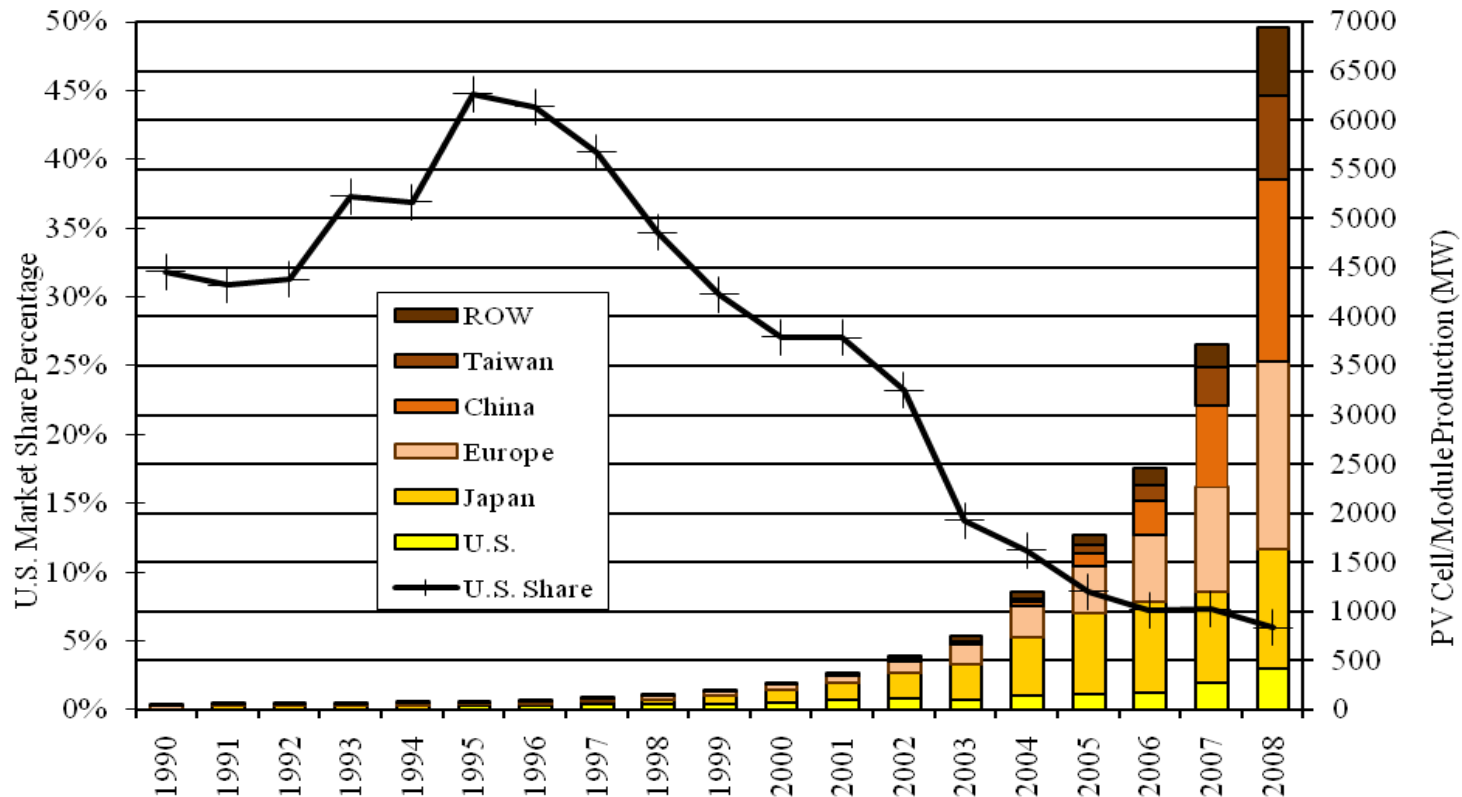
Global Venture Capital and Private Equity Investments by Solar Technology



Source: NEF / NREL / FACC

The U.S. share of worldwide PV cell/module production has fallen drastically

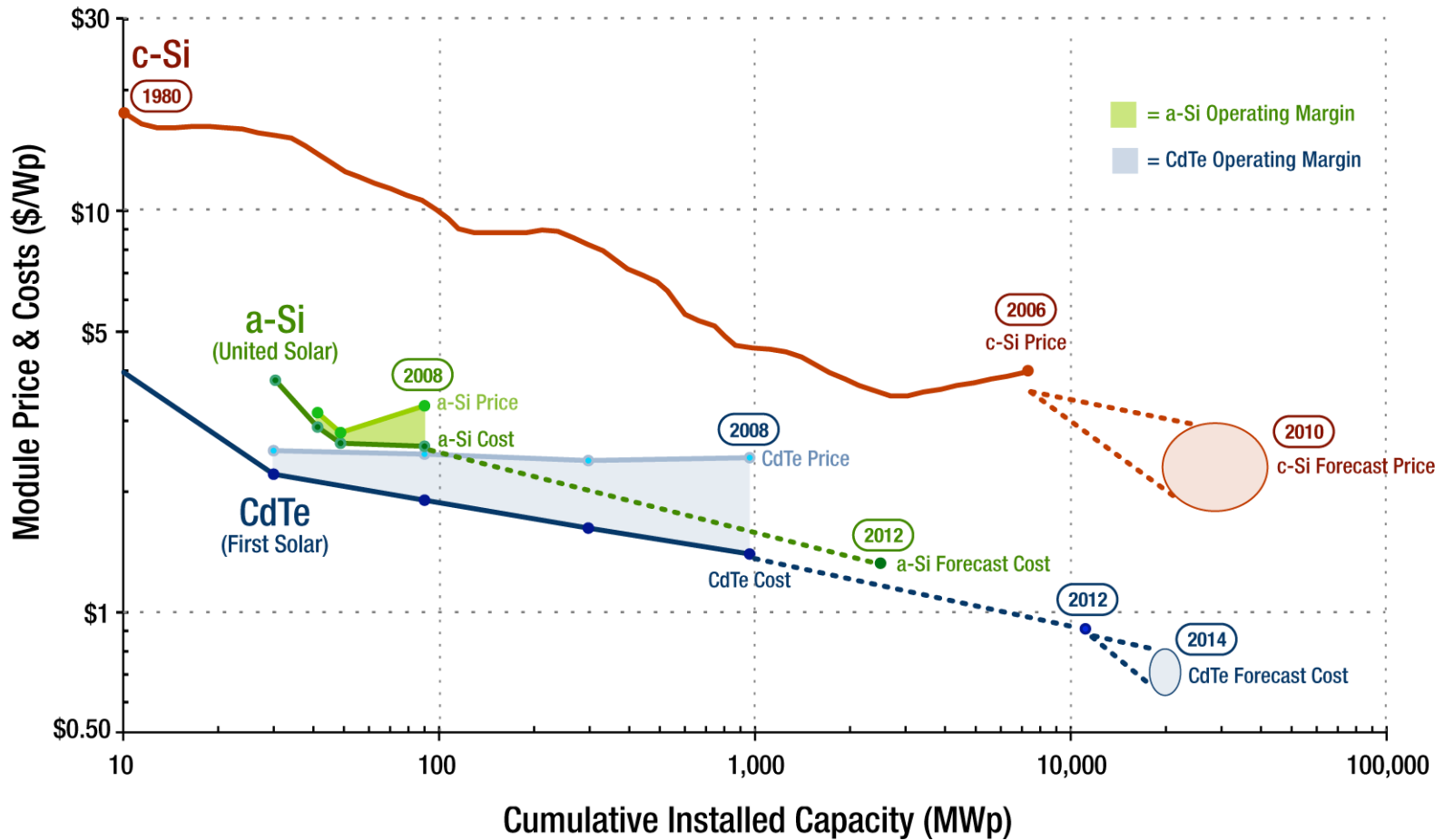
- China's PV cell/module production has been outpacing global growth during the past 5 years (with 5-yr CAGR through 2008 of 170% vs. global 5-yr CAGR of 56%).
- China took the lead in global production in 2008 with 1.8 GW of production (tied with Europe at 27% market share of 6.9 GW global production).



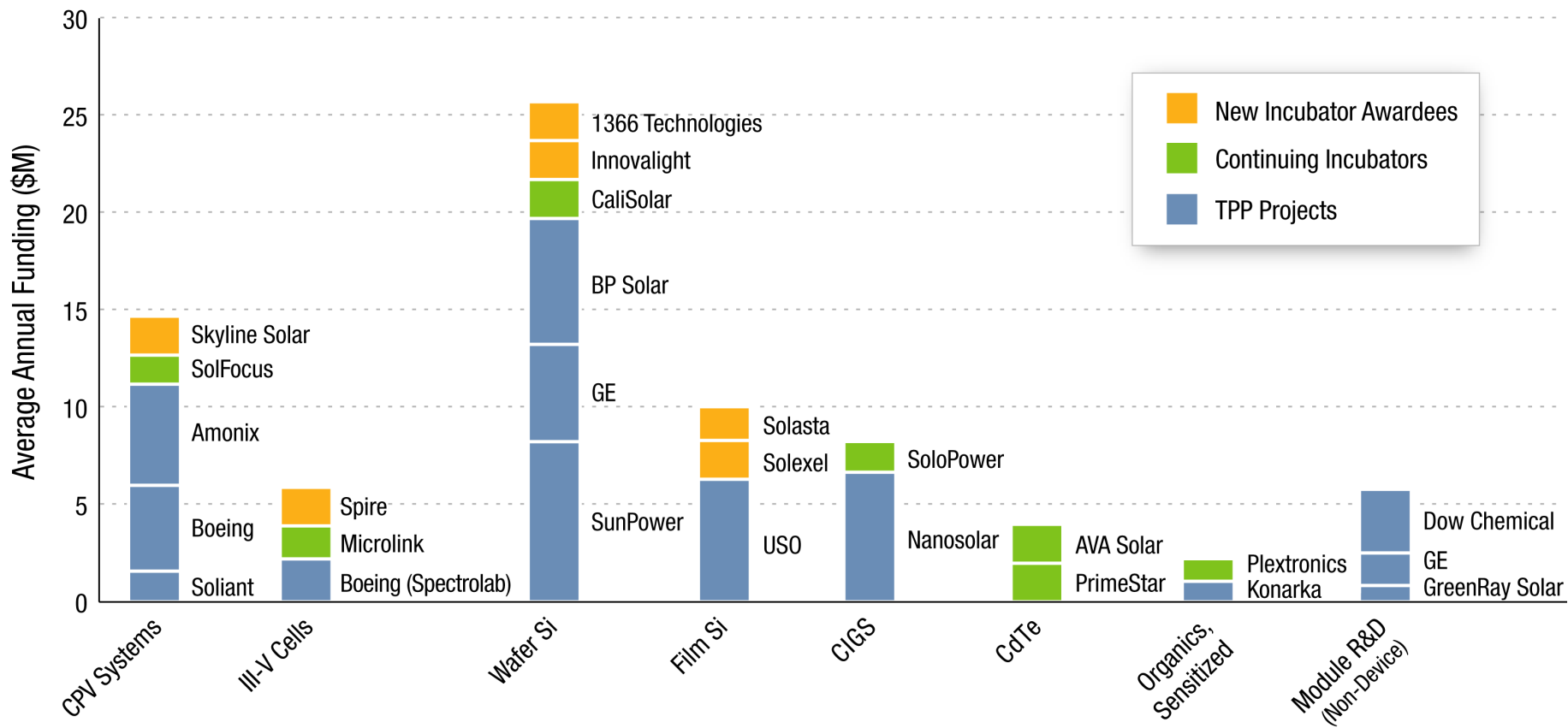
Prometheus/PV News 1993 - April 2009

PV costs have been dramatically reduced across different technologies

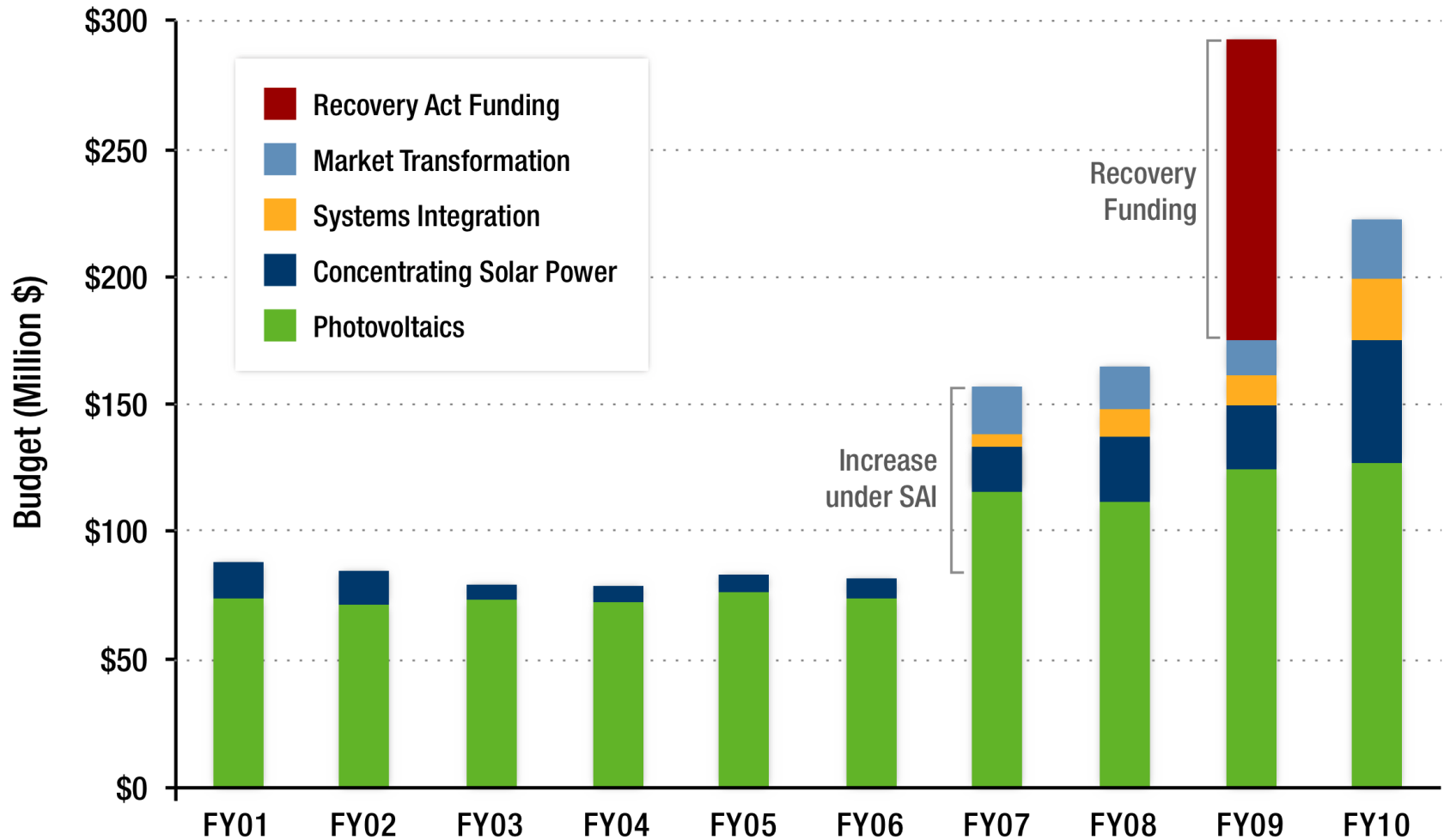
Historical and Projected Experience Curve for PV Modules



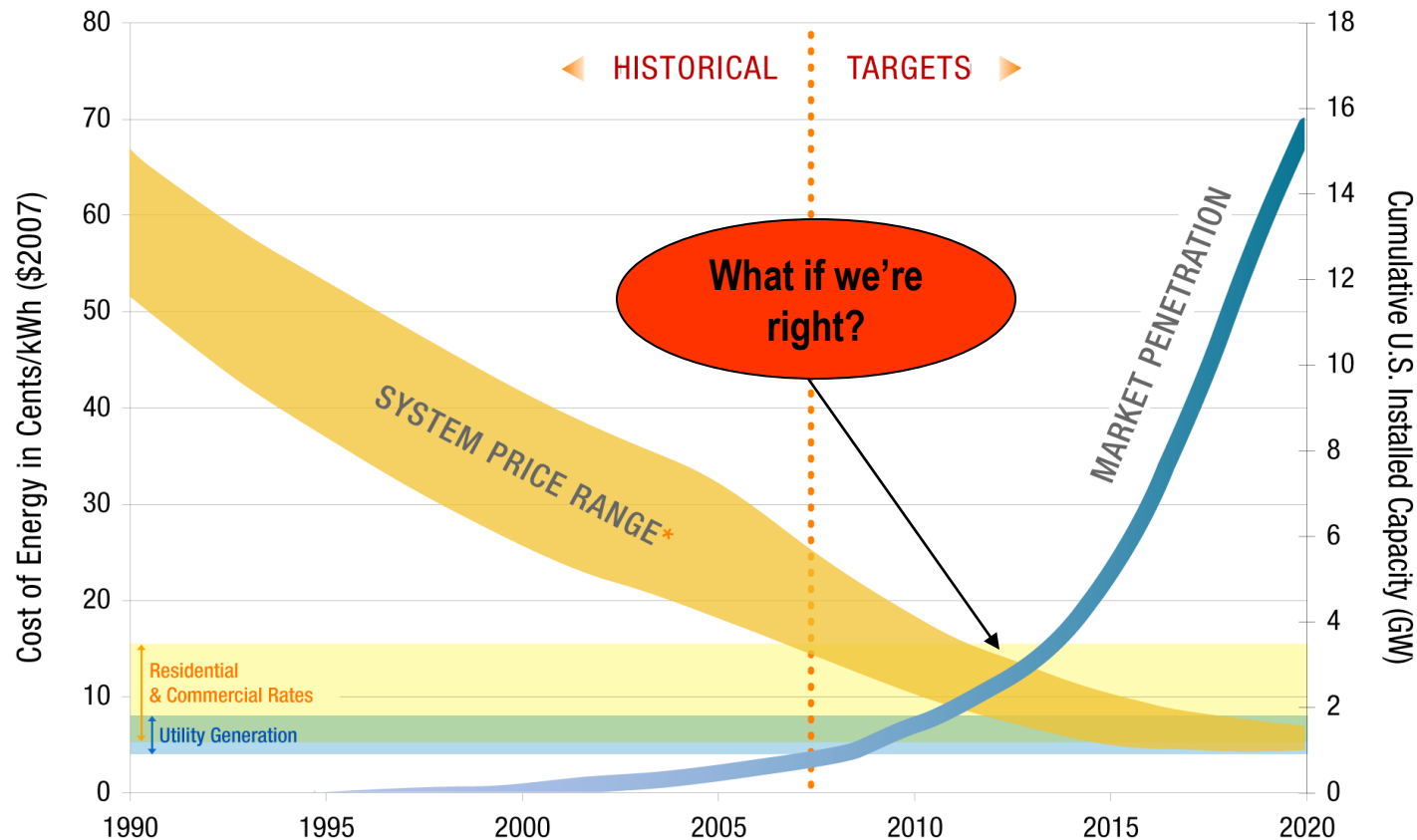
DOE's industry R&D programs include diverse technologies



SETP budget



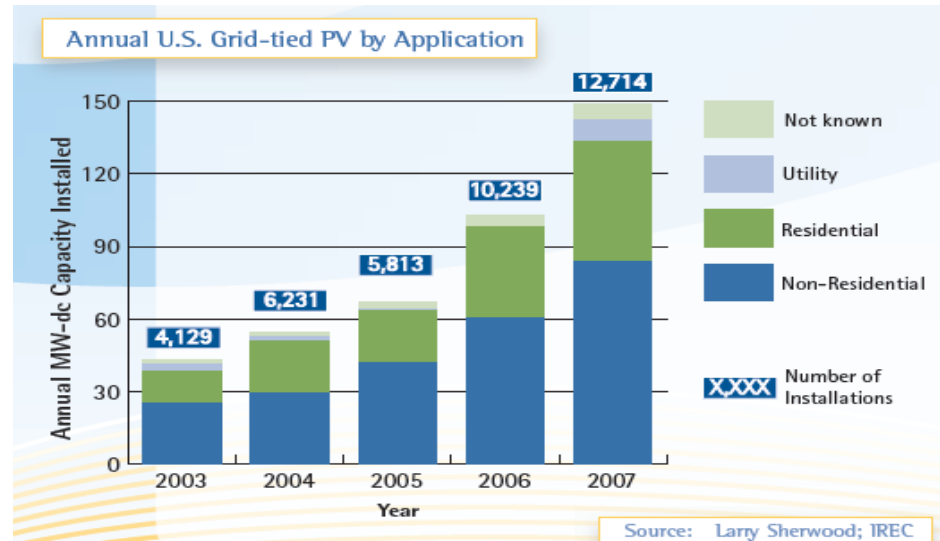
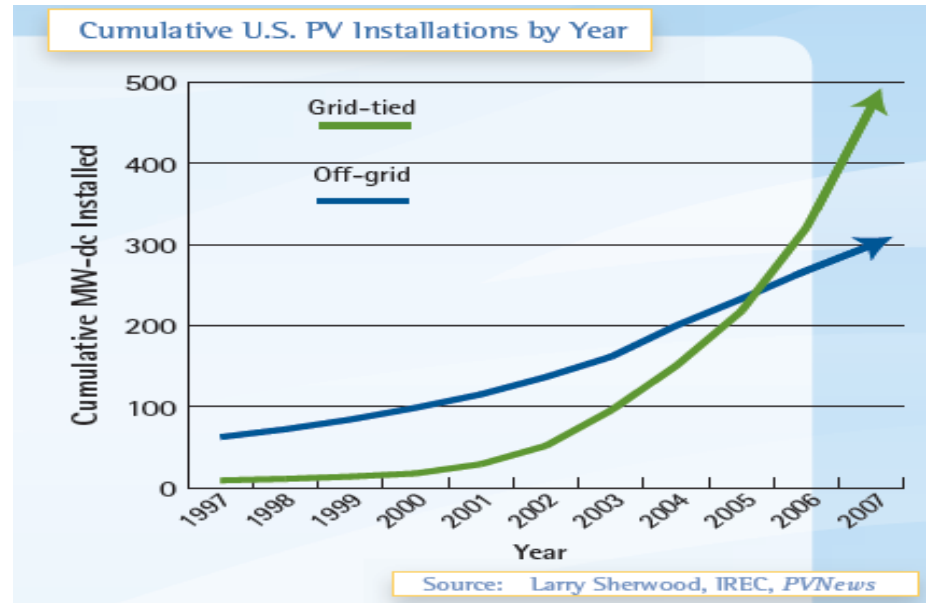
The SETP is focused on enabling high penetration of solar energy technologies and achieving grid parity by 2015



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

Growth of Grid-Tied PV at a Fast Clip

- **Based on latest industry information on grid-tied PV:**
 - 45% growth rate in U.S. PV installations in 2007 over 2006
 - Annual installed capacity more than doubled since 2005
 - In 2008, CA alone installed 158MW, exceeding the 150MW growth achieved by entire U.S. in 2007
 - Outside CA, annual installations grew 83% in 2007 over 2006
- **High-penetration PV will inevitably become more prevalent in foreseeable future, based on growth trajectory**



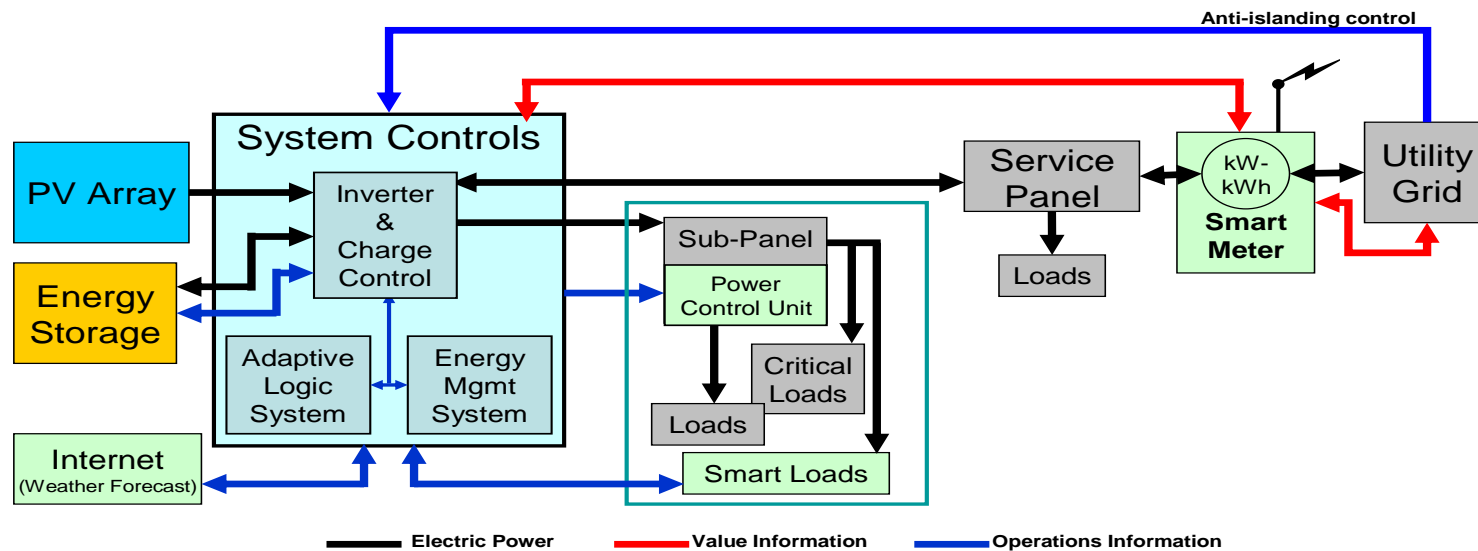
Technical Challenges for High-Penetration PV

- **Ensure safe and reliable two-way electricity flow**
- **Develop smart grid interoperability**
- **Develop advanced communication and control functionalities of inverters**
- **Integrate renewable systems models into power system planning and operation tools**
- **Integrate with energy storage, load management, and demand response to enhance system flexibility**
- **Understand high-penetration limiting conditions**
- **Understand how various climates and cloud transients affect system reliability**



SEGIS Development Efforts

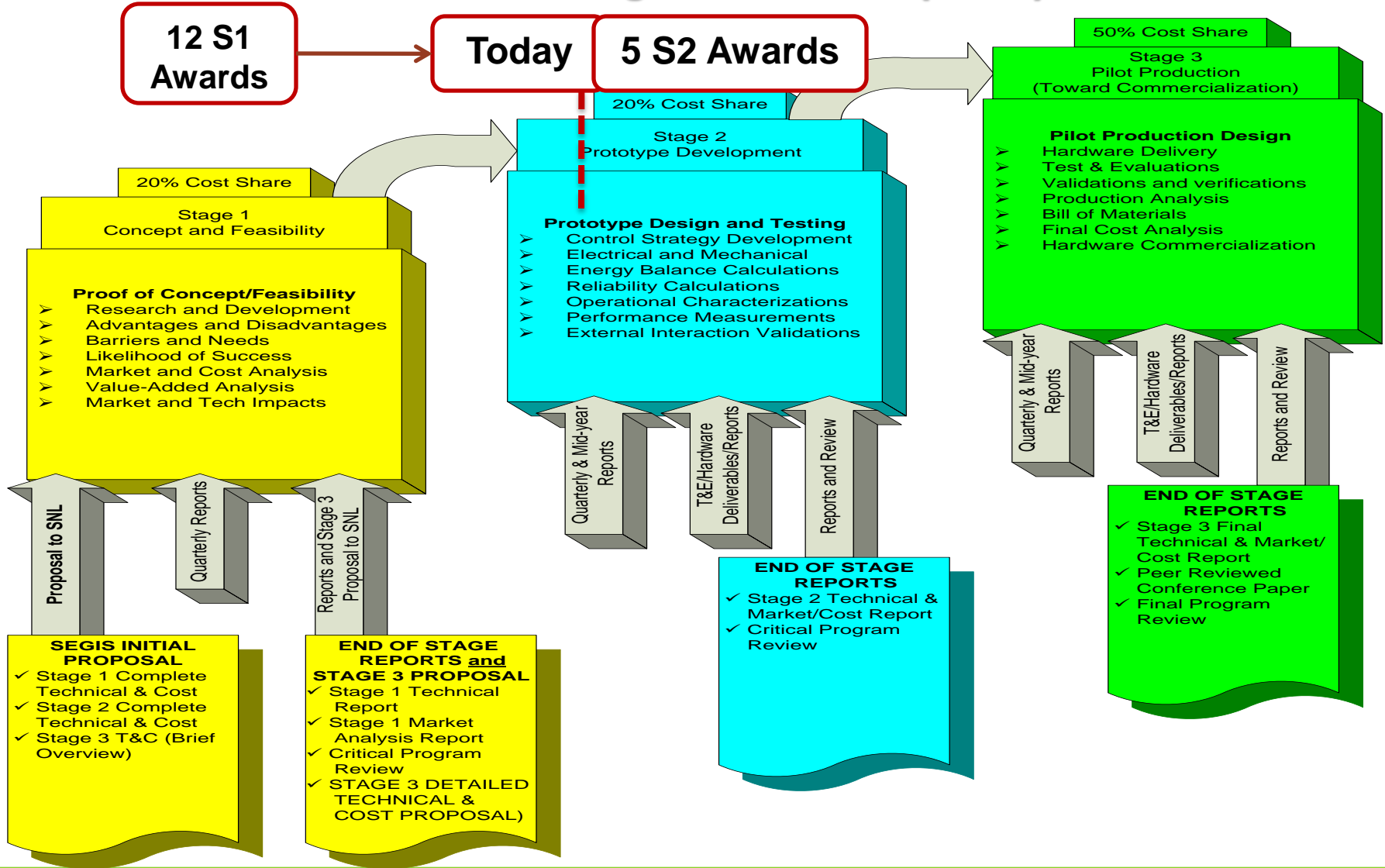
- SEGIS is a “system” development program focused on new requirements for interconnecting PV to the electrical grid.
- SEGIS develops intelligent hardware that strengthens the ties of smart grids, microgrids, PV, and other distributed generation.



Advanced Distribution Infrastructure with SEGIS Functionalities

SEGIS Stages & Timetable

SEGIS is a 3-Stage Solicitation (\$24M)



Apollo Solar

Apollo Solar

- **Smart Grid Inverter provides the capability for energy storage.**
 - The battery storage can be installed during initial system installation or at a later date.
- **Smart Grid Inverter topology provides increased efficiency and high reliability.**
 - Due to low-part-count and minimal internal heat.
- **The communication system allows monitoring and control by the individual system owner, by the ISO's, or by the electric utilities via IEC 16850-7-420 and other developing protocols.**



Florida Solar Energy Center

Florida Solar Energy Center

- **The FSEC team is working to develop new grid integration concepts for PV that utilize:**
 - optional battery storage
 - utility control
 - communication and monitoring functions
 - building energy management systems



Petra Solar

Petra Solar

The company's SEGIS system architecture is achieved through a number of technological innovations, including:

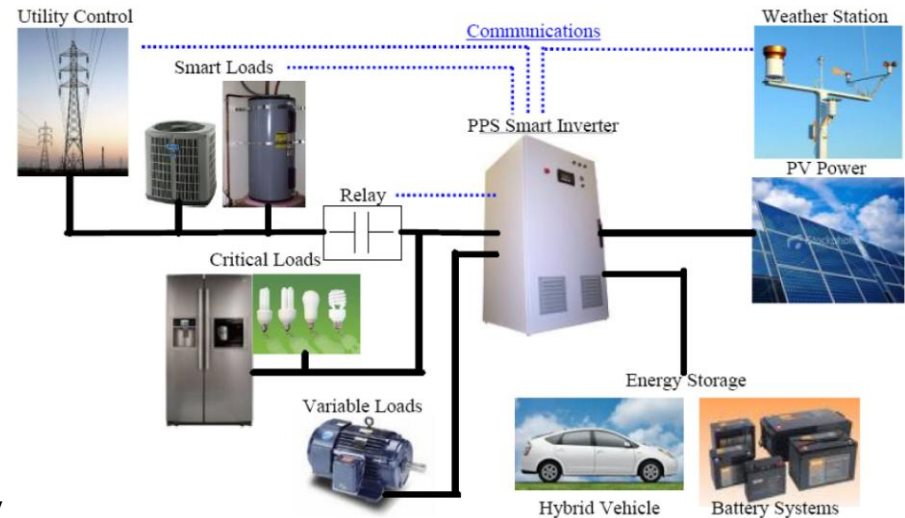
- **Easy-to-install, modular and scalable solar power system architecture based on PV AC modules.**
- **Multi-layer control and communication system that provides electric utilities with the tools to deploy a smart grid communications network and manage distributed generation assets.**
- **Cutting-edge power management platform, which provides tools and functionality to achieve a reliable two way distribution grid architecture.**



Princeton Power Systems

Princeton Power Systems

- **Building an advanced Demand Response Inverter (“DRI”) incorporating nanocrystalline materials, that will lower energy cost.**
- **The DRI should achieve a lower LCOE through the following attributes:**
 - Small nanocrystalline magnetics and low-voltage silicon contribute to high efficiencies, with a California Energy Commission (CEC) weighted efficiency of 98%.
 - Simplicity of design and reduction of parts counts reduces initial capital cost.
 - Verified highly reliable components (15 year service life; ~400k hours Mean Time Between Failures).



PV Powered

PV Powered

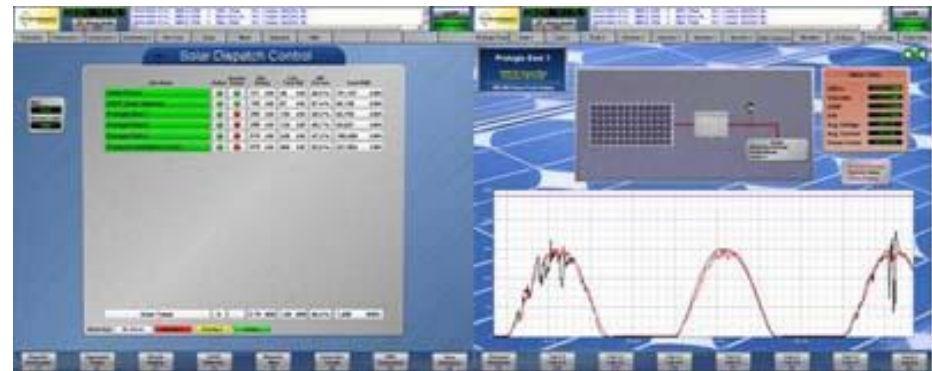
Focus is on two key areas:

1) Solving utility systems integration problems

- Two-way Utility Communications and Control.
- Smart Power Islanding Detection.
- Site Demonstration.

2) Improving the energy economics of PV systems

- Energy Harvest.
- Energy Management Systems Integration.
- Improved Power Plant Balance of System Components.



Thank You

Contact Information:

John Lushetsky

Solar Energy Technologies
Program Manager
U.S. Department of Energy

Email:

john.lushetsky@ee.doe.gov

Phone: **202-287-1685**

on the web:

www.solar.energy.gov

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