International Workshop on Glass for Harvesting, Storage & Efficient Usage of Solar Energy

Needs and Opportunities for Glass in the US DOE Solar Technology Program

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Agenda

- US Solar Program Overview
- Solar Glass Requirements
- Market Dynamics
- Potential Follow-On Federal Solar Incentives

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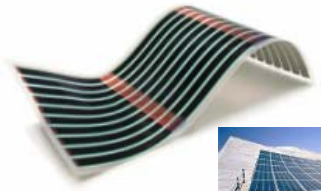
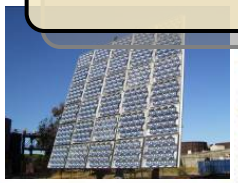
The mission of DOE's Solar Program is to

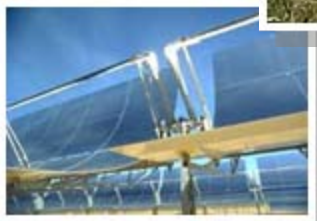
Accelerate the wide-spread adoption of solar electric technologies across the United States



Photovoltaics (PV)

DOE SETP





Concentrating Solar Power (CSP)

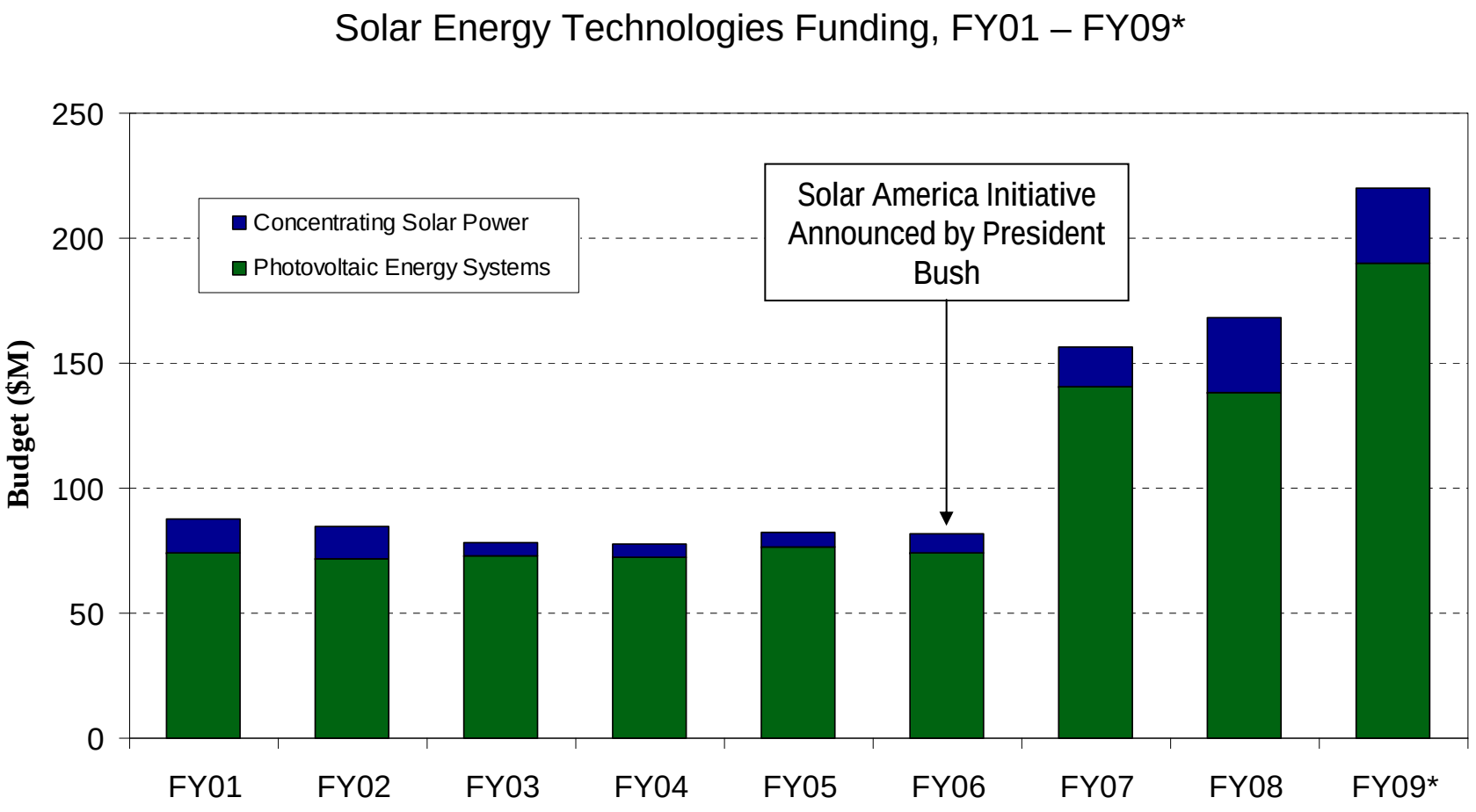
Market Transformation

Grid Integration

Distributed Generation
on-site or near point of use

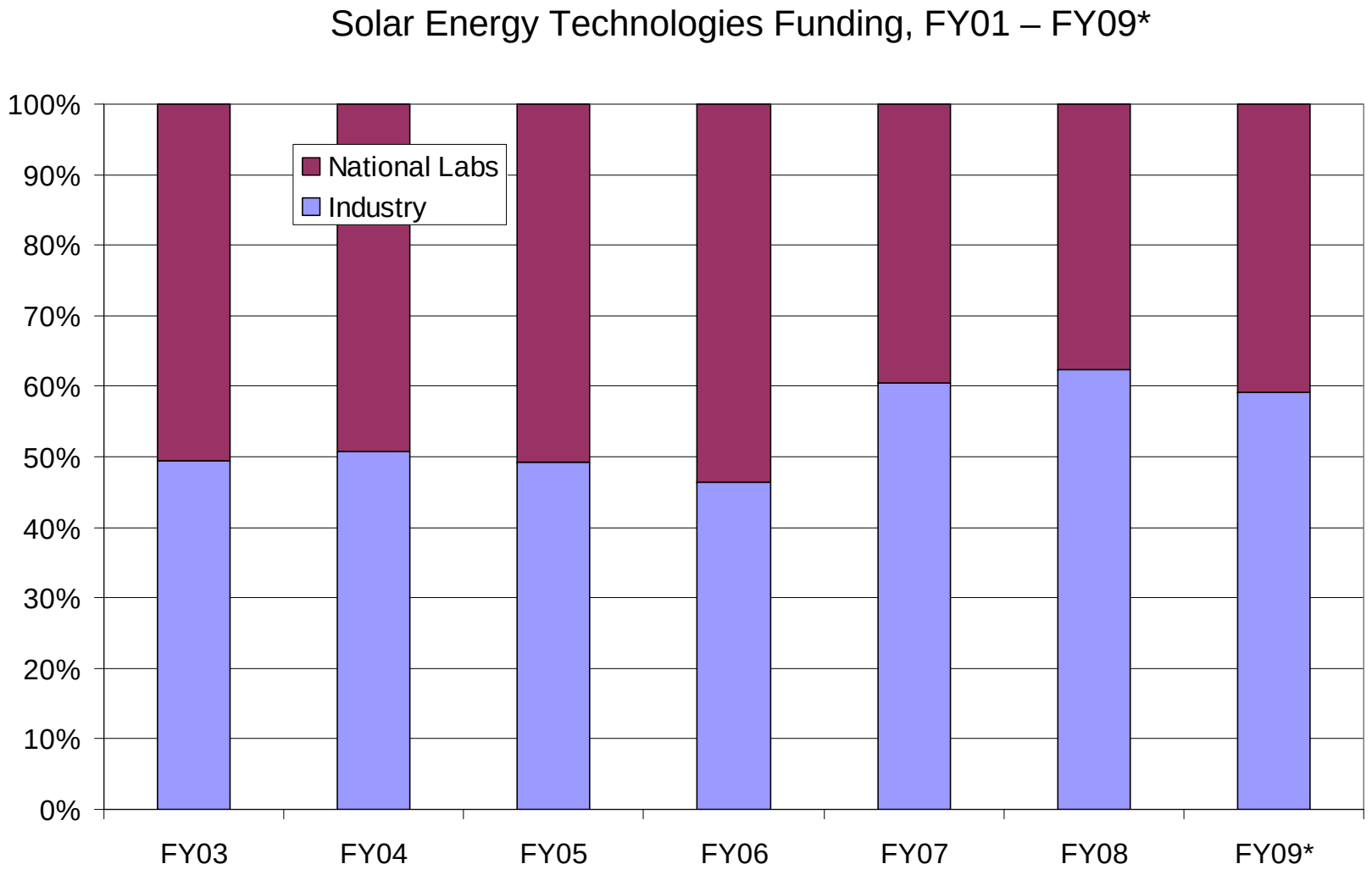
Centralized Generation
large users or utilities

Funding for the SETP has been increased in response the Solar America Initiative



*President's request for FY09 was $150M, current House mark is $220M, current Senate mark is $229M.

The SETP has slightly increased funding to industry in response to the Solar America Initiative



*President's request for FY09 was $150M, current House mark is $220M, current Senate mark is $229M.

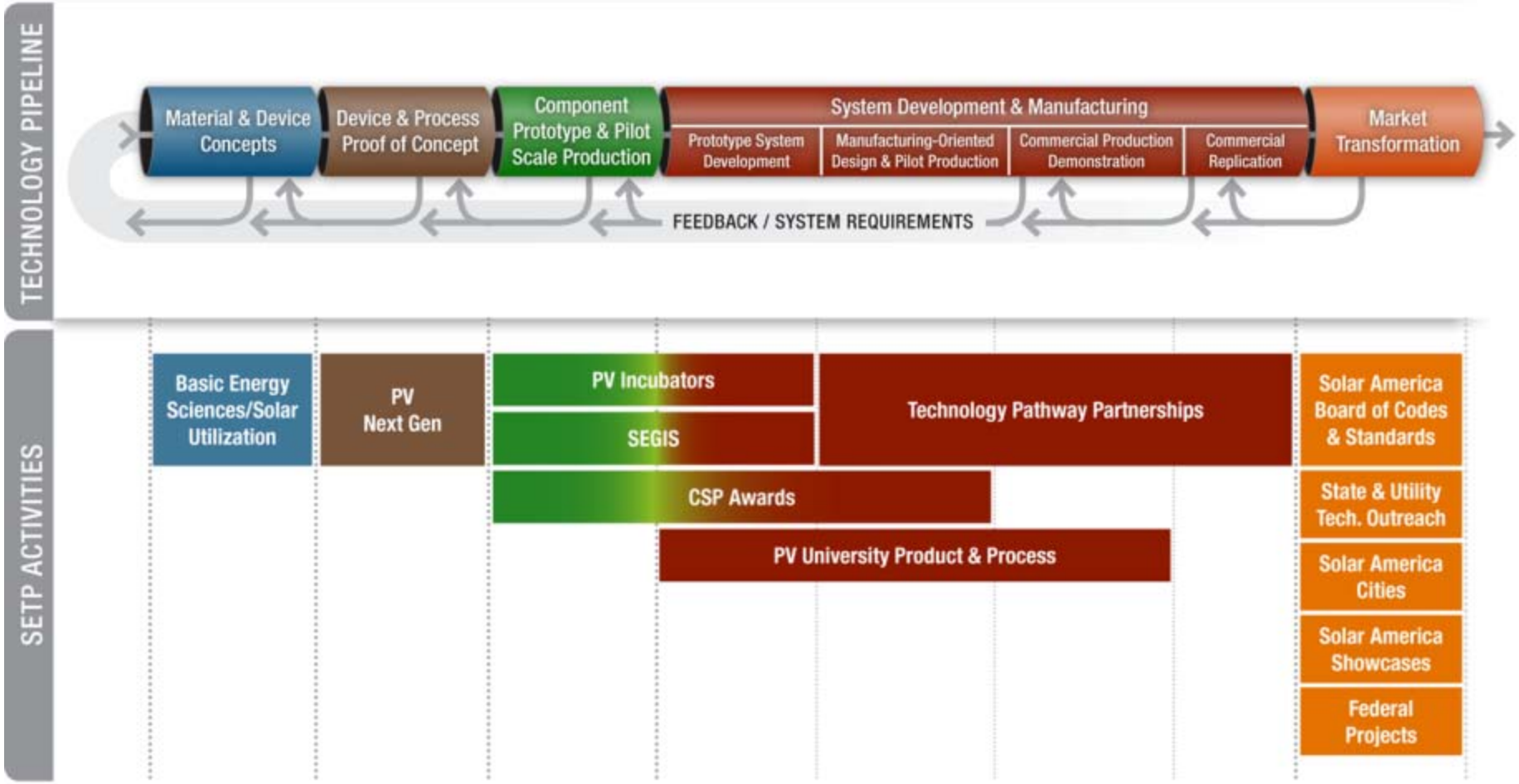
NREL and SNL provide a strong base for solar development partnerships with industry

- **Over 200 scientists and engineers with deep understanding of all solar technologies**
- **Areas of expertise**
  - Crystalline silicon and thin-film PV
  - Flat-plate and concentrator PV
  - Process development and engineering
  - System development and testing
  - Measurement and characterization
  - Reliability engineering
  - Next-generation PV technologies
  - CSP components and testing
  - Grid integration and power electronics

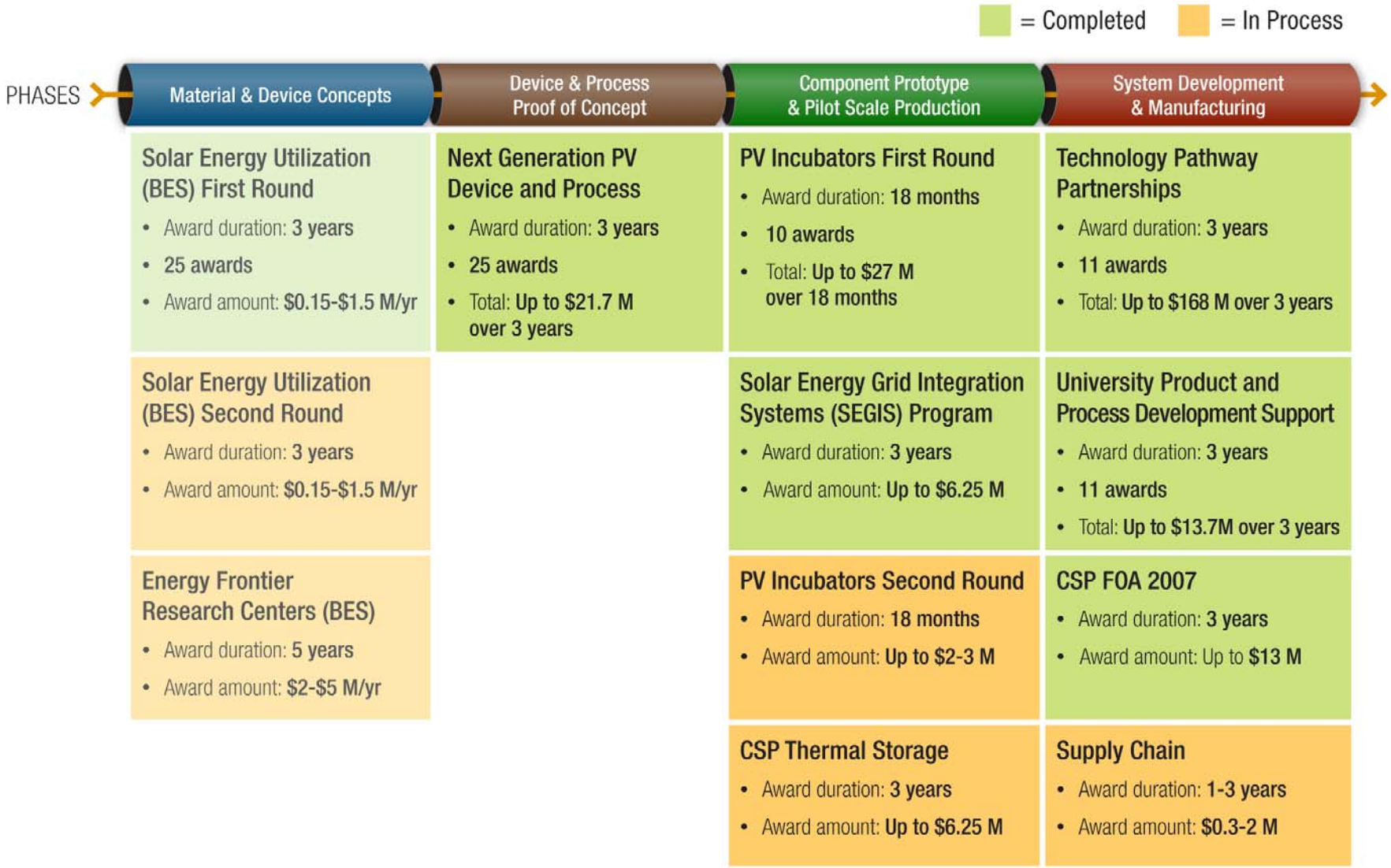
Collaboration Types

- Cooperative R&D Agreements (CRADA)
- Work-for-Others
- Technical Service Agreements
- Technology Licensing

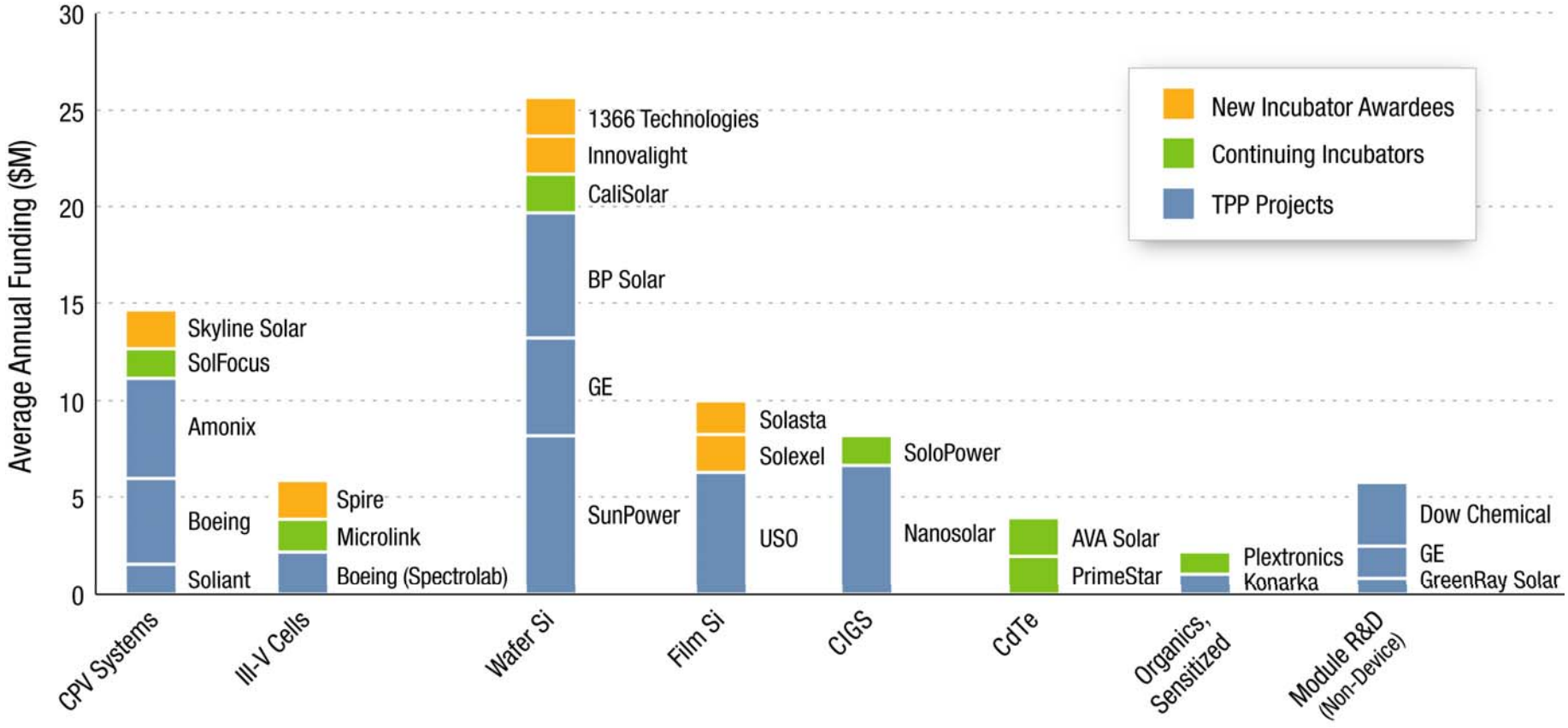
SETP is structured to work along the whole RDD&D pipeline



SETP is sponsoring a number of industry led efforts to accelerate the development of solar technologies

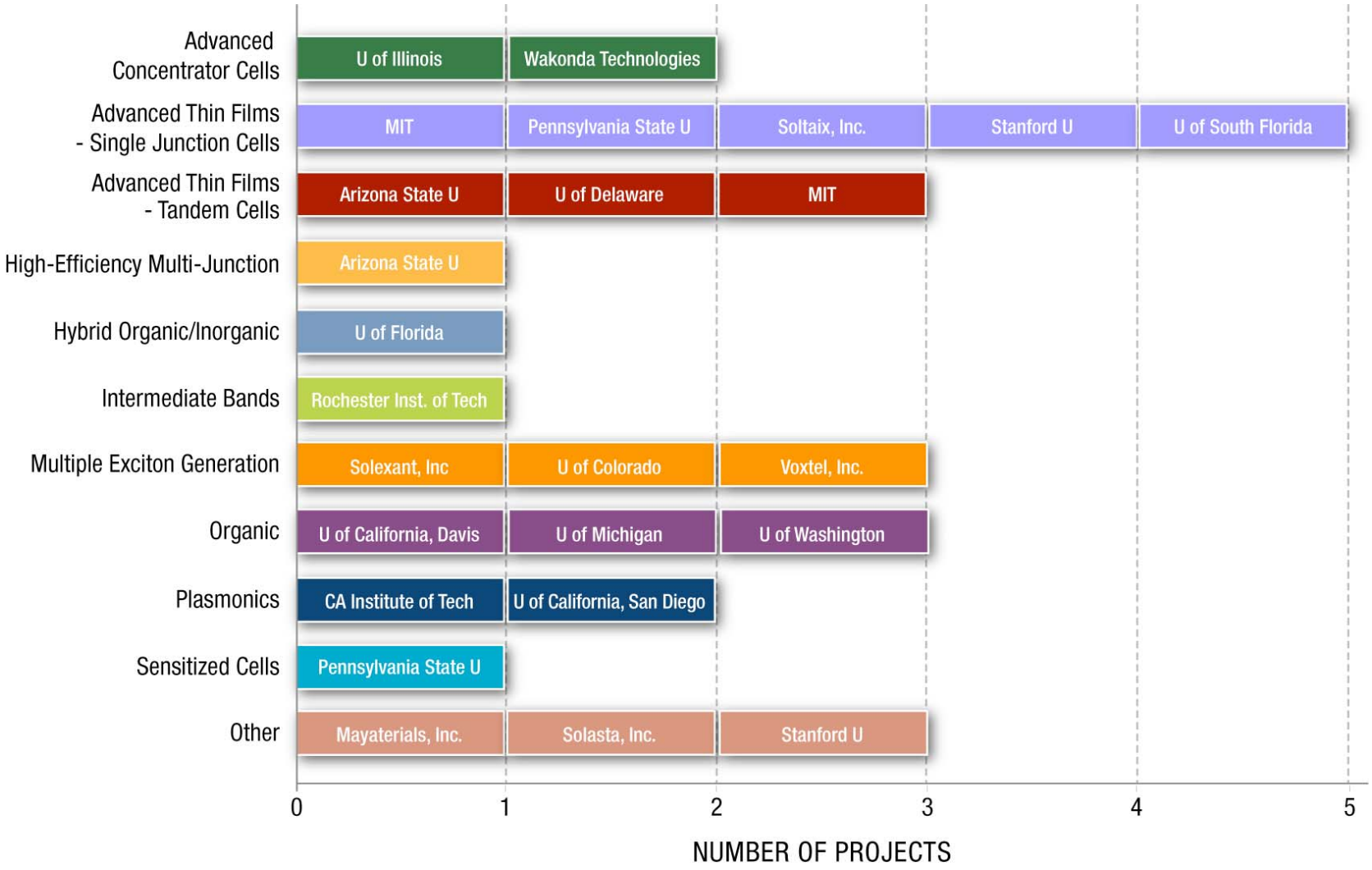


DOE's industry R&D programs include diverse technologies for potentially diverse PV markets



- Second round of PV incubators announced September 26th, 2008
- Currently conducting stage gate reviews for TPP projects
- Announcement of supply chain funding opportunity

DOE's Next Generation PV seeds the beginning of the pipeline with high risk/ high payoff projects



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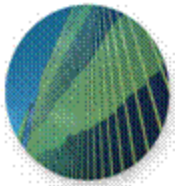
FY2008 PV funding across all programs and including national labs



Thin Films (aSi) 5%

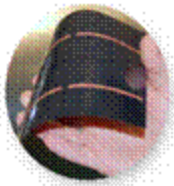
Advancing amorphous and wafer replacement crystal silicon film solar cells on low-cost substrates

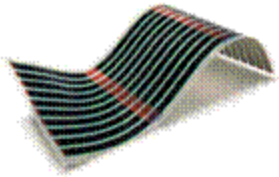
5% Thin Films (CdTe)

Simplifying deposition while retaining performance and transferring record device architecture to manufacturing processes

7% Thin Films (CIGS)

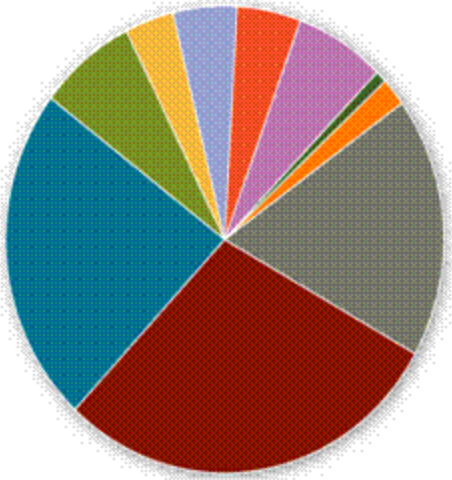
Supporting the manufacture of non-vacuum processes and transferring record efficiency device performance into large area commercial modules





Organic PV 4%

Customizing molecules, substrates, and deposition techniques to yield ultra low-cost modules



1% Dye-Sensitized Cells

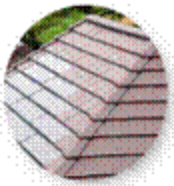
Advancing the efficiency and stability of inexpensive dye-based solar cells with novel nanostructures

Next Generation 7%

Investigating advanced concepts aimed at delivering revolutionary performance improvements

2% Building Integrated PV

Creating module form factors aimed at dramatically reducing or eliminating solar installation costs



Crystalline Silicon 23%

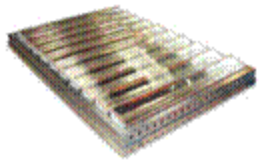
Developing higher efficiency devices and lower cost processing methods for traditional silicon cells

28% Crosscut

Synergistic technologies, evaluation approaches, and process engineering approaches applicable across multiple absorber materials and processes

18% Concentrating PV

Combining new, lower cost multijunction cells and innovative optical packages



R&D is targeting technical obstacles in CSP systems to improve performance and reduce costs

Line Focus

- Optimize receiver and concentrator designs for higher temps, increase component suppliers, and create advanced evaluation capabilities.

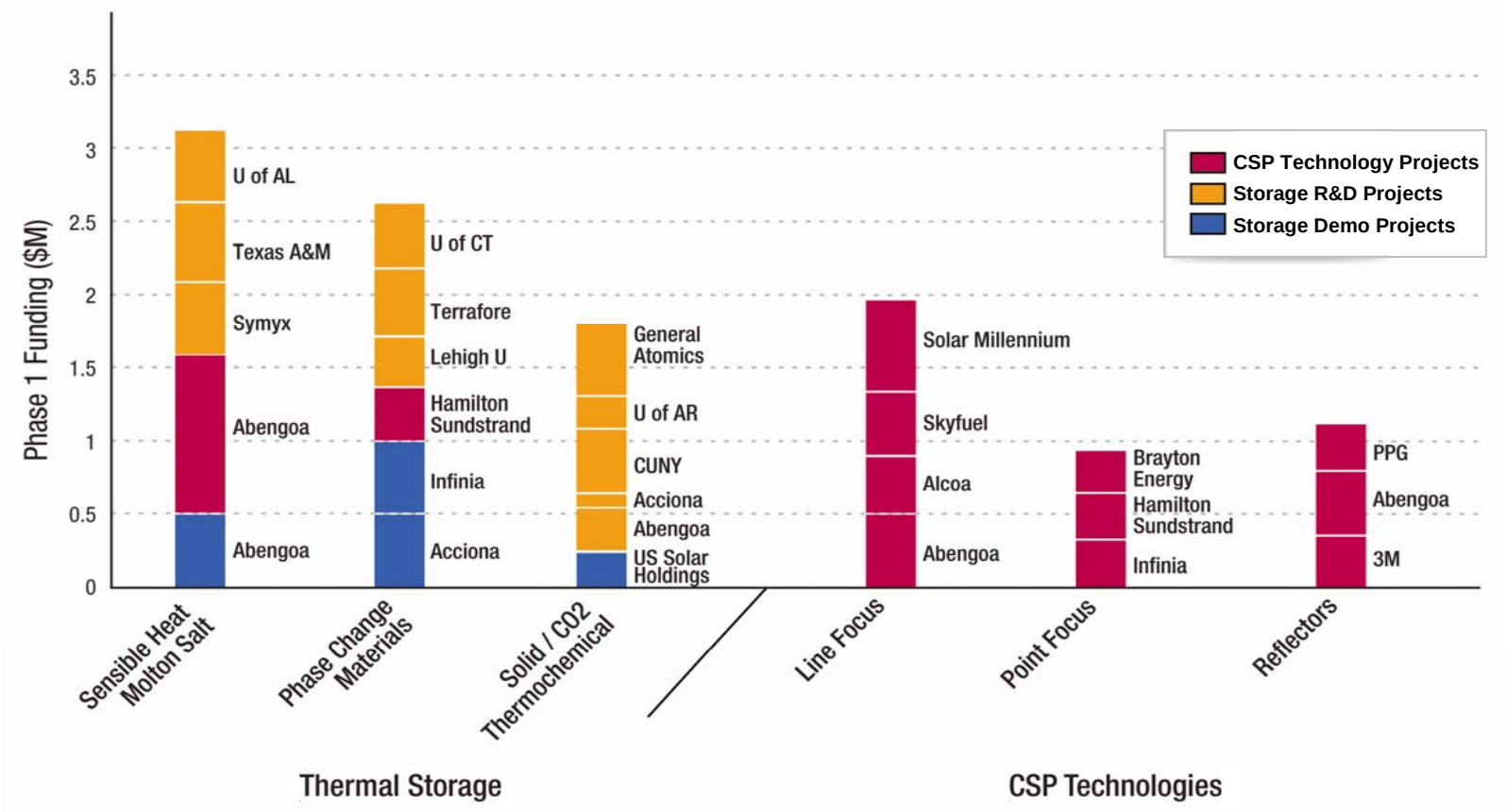
Point Focus

- Improve engine reliability and system manufacturability, and develop next-generation dish system designs. Test new tower receiver panel.

Storage

- Develop advanced heat transfer fluids for more efficient operation at high temperatures, and test innovative designs for low-cost storage using sensible and latent heat options .

DOE funds CSP Industry R&D to reduce system costs



- First Funding Opportunity Announcement (FOA 1) is in stage gate review
- FOA 2 awardees were announced September 2008
- Third CSP FOA anticipated for March 2009

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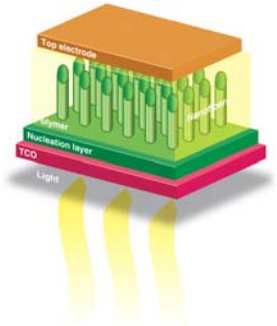
Glass needs for Photovoltaics

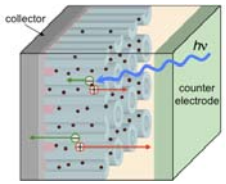
- Increased strength to weight (thickness) to permit larger thin film module size
  - Applied Materials Gen 8 thin film silicon modules
- Improved TCO's
  - Improve device efficiency by minimizing optical and electrical loss
  - Improve device stability
  - Control interfacial properties
  - Have improved surface properties, processibility, work function etc.
  - Be enabling for 3rd generation approaches
- Textured glass needed for improved light capture
  - Thin wafered silicon and single crystal thin film silicon
- Anti-soiling and hardness coatings
  - Will become critical in desert environments

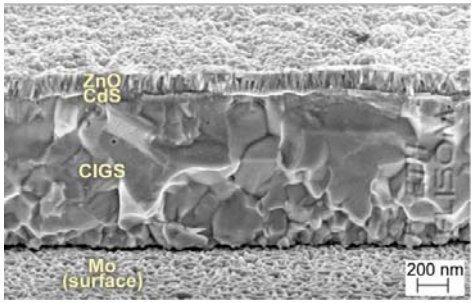
Use of TCO in Photovoltaics

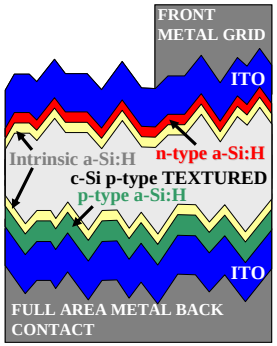
TC Material	Specific PV Technology Areas (Roadmaps)					
	WSi	FSi	CPV	CdTe	CIGS	OPV
In-Zn-O	X	X			X	X
Zn-O:Ga/ZnO	X	X	X	X	X	X
Zn-Sn-O				X		X
Cu-Zn-O		X		X		X
In-Sn-O	X	X			X	X
In-Ti-O			X		X	X

- DOE is funding $1M cross-cutting research for TCO's for different PV technologies through NREL







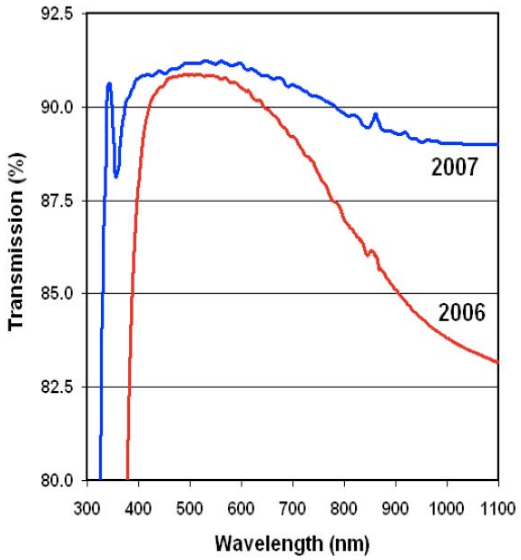


OPV Dye CIGS HIT/TF Si

Glass requirements for CSP

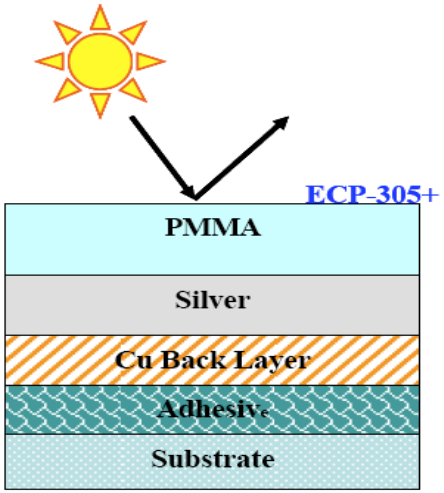
Mirrors

- Anti-soiling and hardness coatings
  - Will become critical in desert environments
- High reliability integrated construction



Heat Collection Elements (HCE's)

- Anti-reflection and low emissivity coatings



PV Supply Chain and Cross-Cutting Technologies

Transfer and optimize technologies specifically for the PV industry

- Attract new entrants as neutral vendors
- Target domestic leadership in value chain segments
- Mitigate risk across currently funded technologies
- Accelerate new products by developing “enabling” technologies

TOPIC AREAS

Module Components

- Flexible barrier or protective coatings
- Transparent conductors
- Contacts (high aspect ratio, printed, non-silver)

Non-Module Components

- Inverter components
- Trackers
- Streamlined balance of system solutions

Manufacturing

- CPV alignment
- Material flux measurement
- Fast optical characterization

- **Impact Factor = ($/W savings) X (project future sales volume)**
- **Value = Impact ($) / DOE funding**
- **Uniqueness - containing sufficient risk to necessitate DOE funding**
- **Feasibility – likelihood of success**

Potential Supply Chain Issues for the Glass Industry

Flat glass available capacity

- Current projections are for solar to be <5% of total glass capacity through 2015
- Supply chain issues will be determined on “available” capacity
- Single float glass plant (850 MTD) could produce >5 GW equivalent per year at a capital cost of $100M
- Potential for bottlenecks

Raw materials

- Low Iron Silica Refining
  - Only two plants in the US produce low iron silica
  - Limit to potentially 1 GW of capacity

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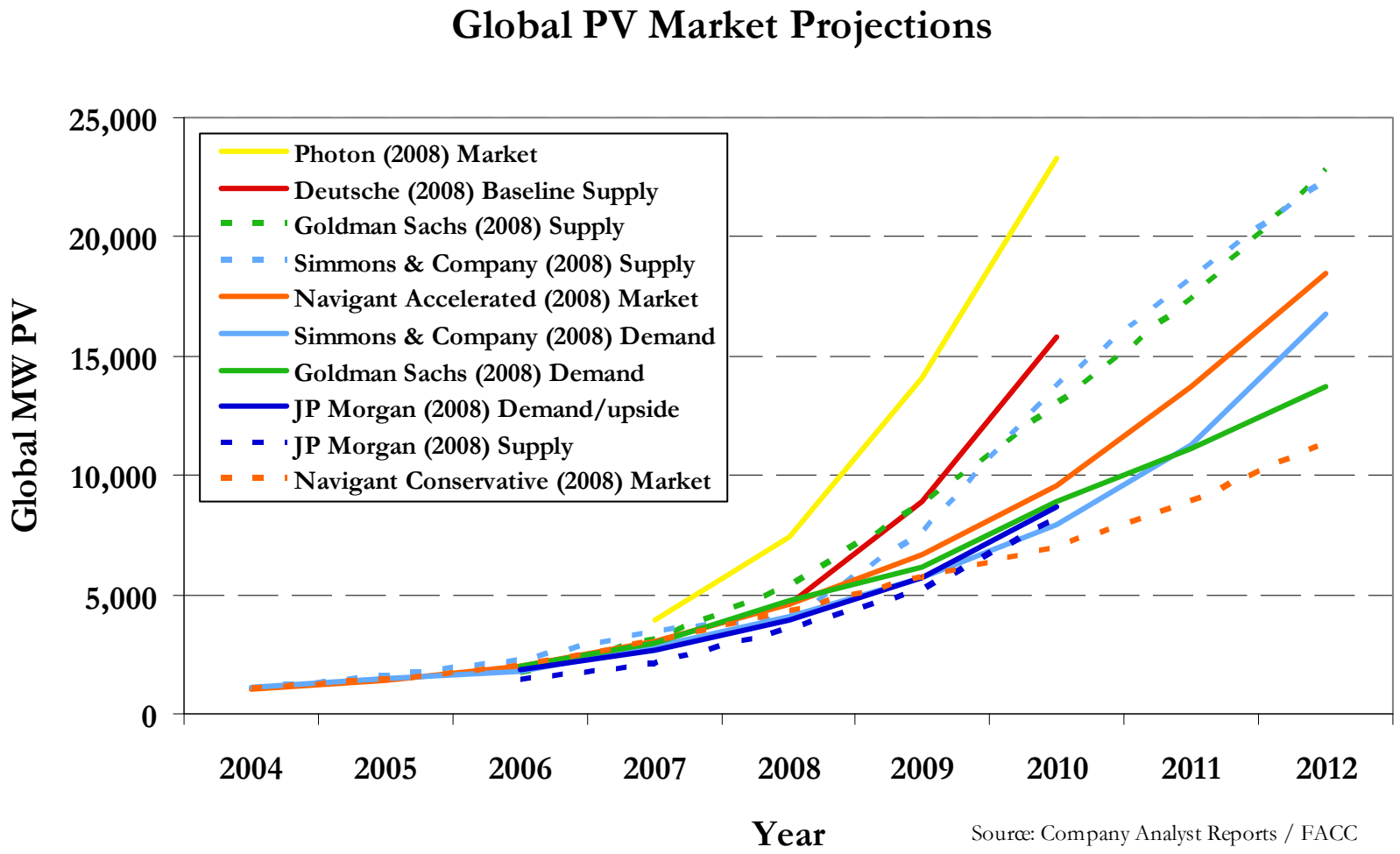
Global PV market projections

Although there are large differences between industry analysts' projections for the global PV market, even the most conservative forecast shows over 25% compound annual growth from 2008 to 2012

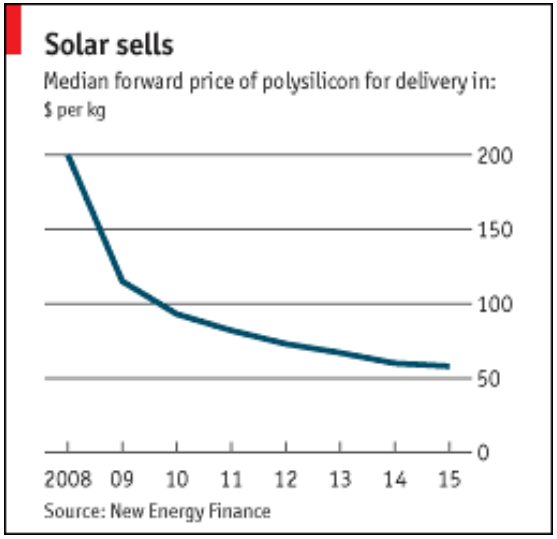


Source: Company Analyst Reports / FACC

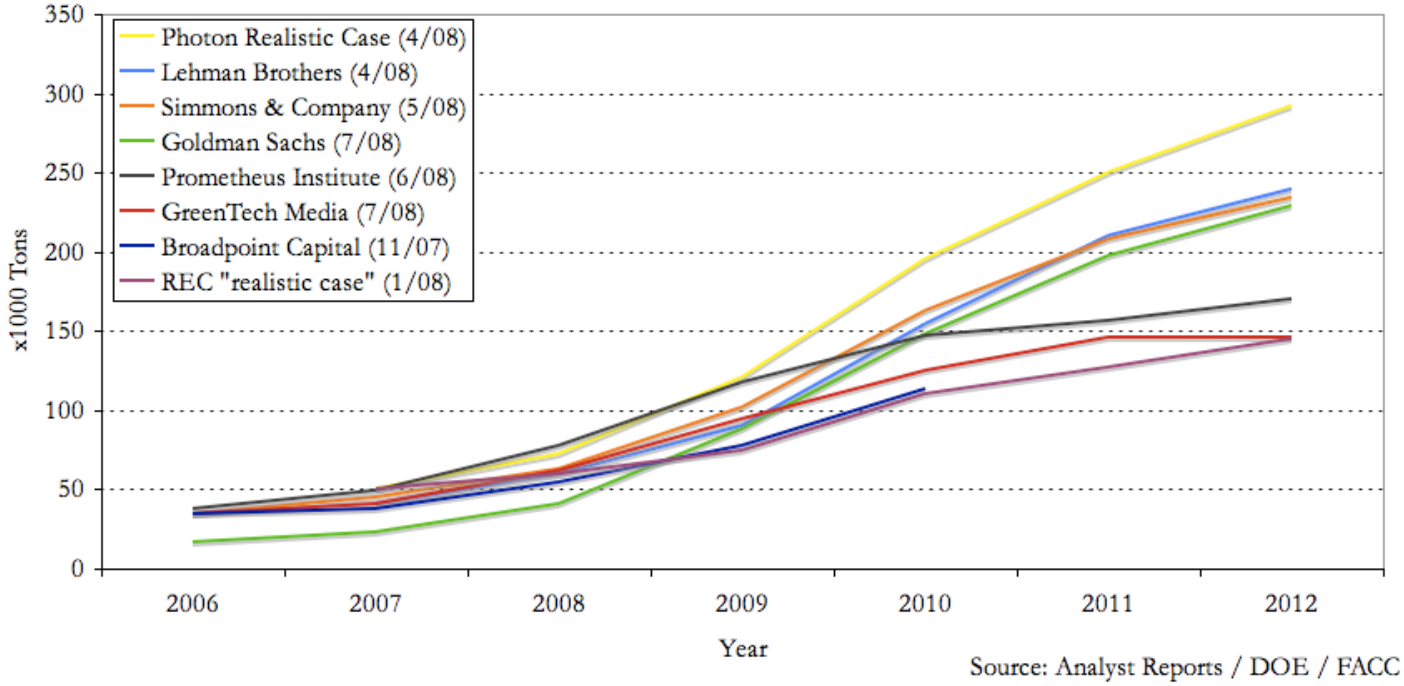
Polysilicon supply and price projections

In response to rising polysilicon prices beginning in 2004, substantial investment was made in expanding polysilicon production capacity

- Increased polysilicon supply in upcoming years will greatly reduce the feedstock costs for c-Si PV



Global Polysilicon Market Forecasts

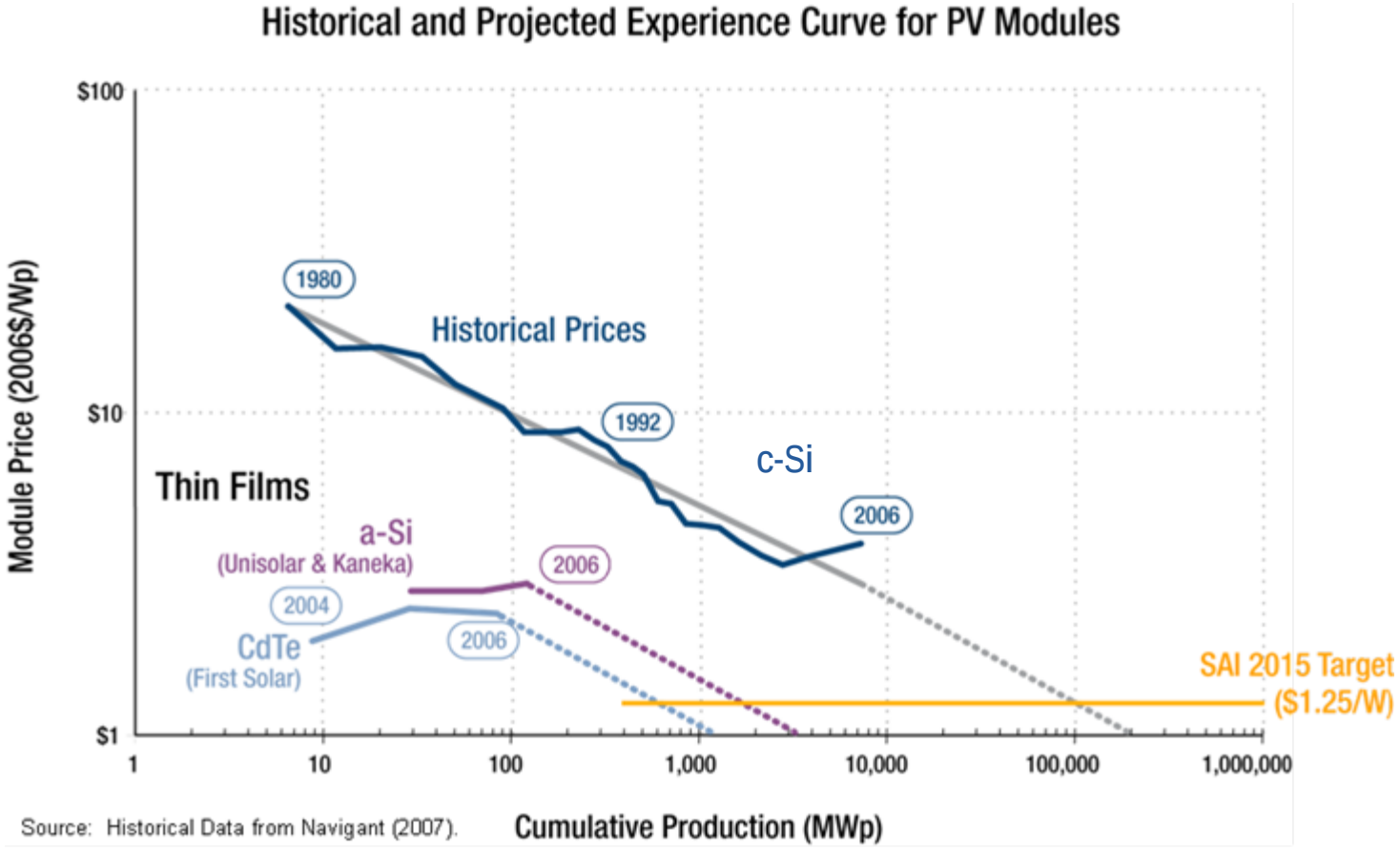


Source: Analyst Reports / DOE / FACC

PV module price projections by technology

Lower polysilicon feedstock prices should allow c-Si PV to continue on its historical path of price reductions

- Based on historical learning curves, CdTe, a-Si and c-Si would reach the Solar America Initiative (SAI) target of $1.25/W with cumulative production of 0.7 GW, 1.8 GW and 100 GW, respectively



Federal ITC Extension

On October 3, President Bush signed into law an extension of the 30% solar investment tax credit (ITC)

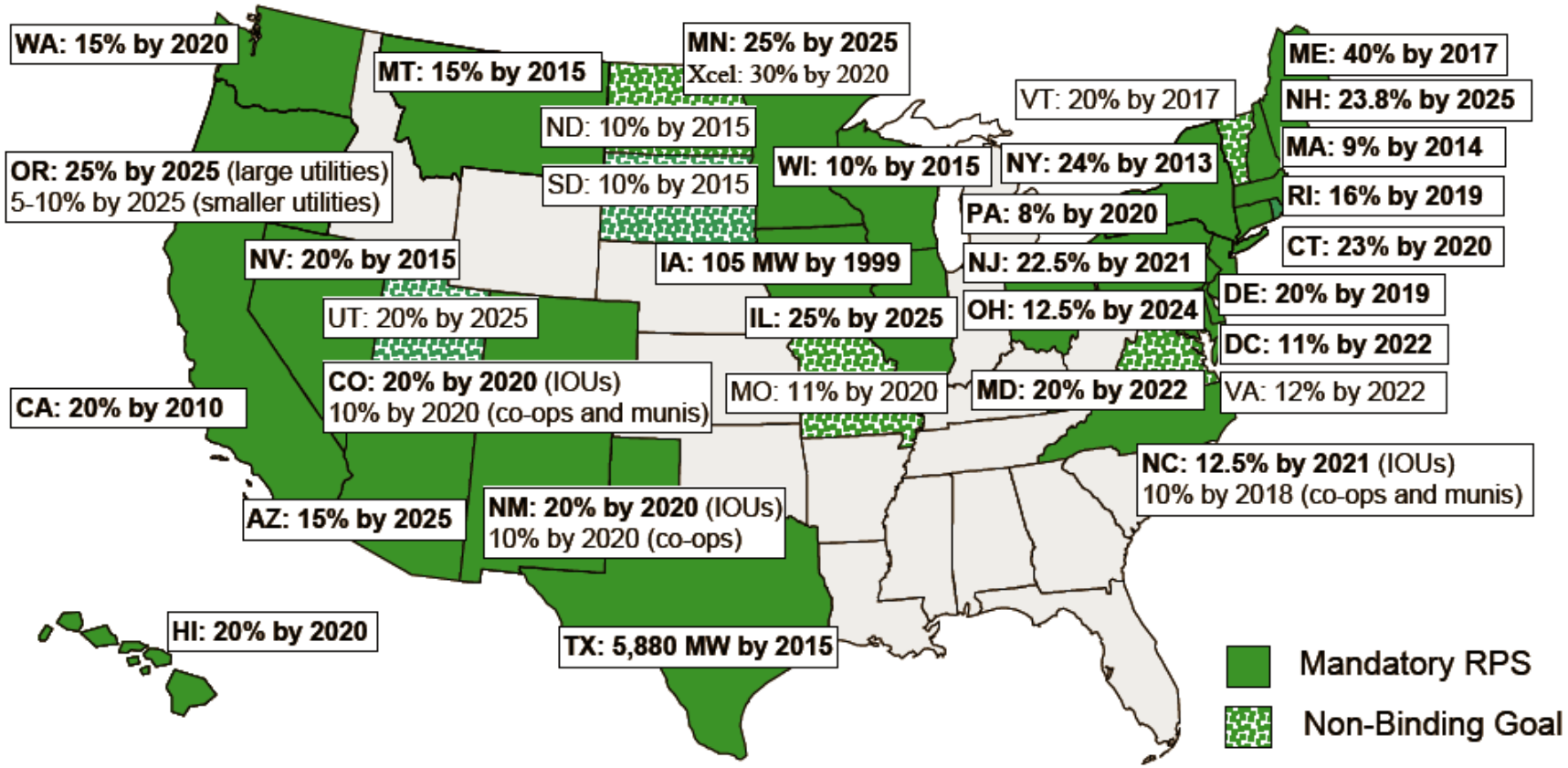
Key Points

- **Term - 8 years**
  - Provides critical extension needed for concentrating solar power (CSP) projects
- **No cap on residential installations**
  - Removes previous $2,000 limit on residential solar projects
- **No utility exclusion**
  - Expands significant market for PV and CSP

According to Navigant Consulting, passage of the ITC will result in 440,000 new jobs

As much as 5.4 GW of previously announced utility-scale solar power projects are now expected to move forward

26 states and D.C. now have mandatory RPS policies, and 6 states have set non-binding RPS targets



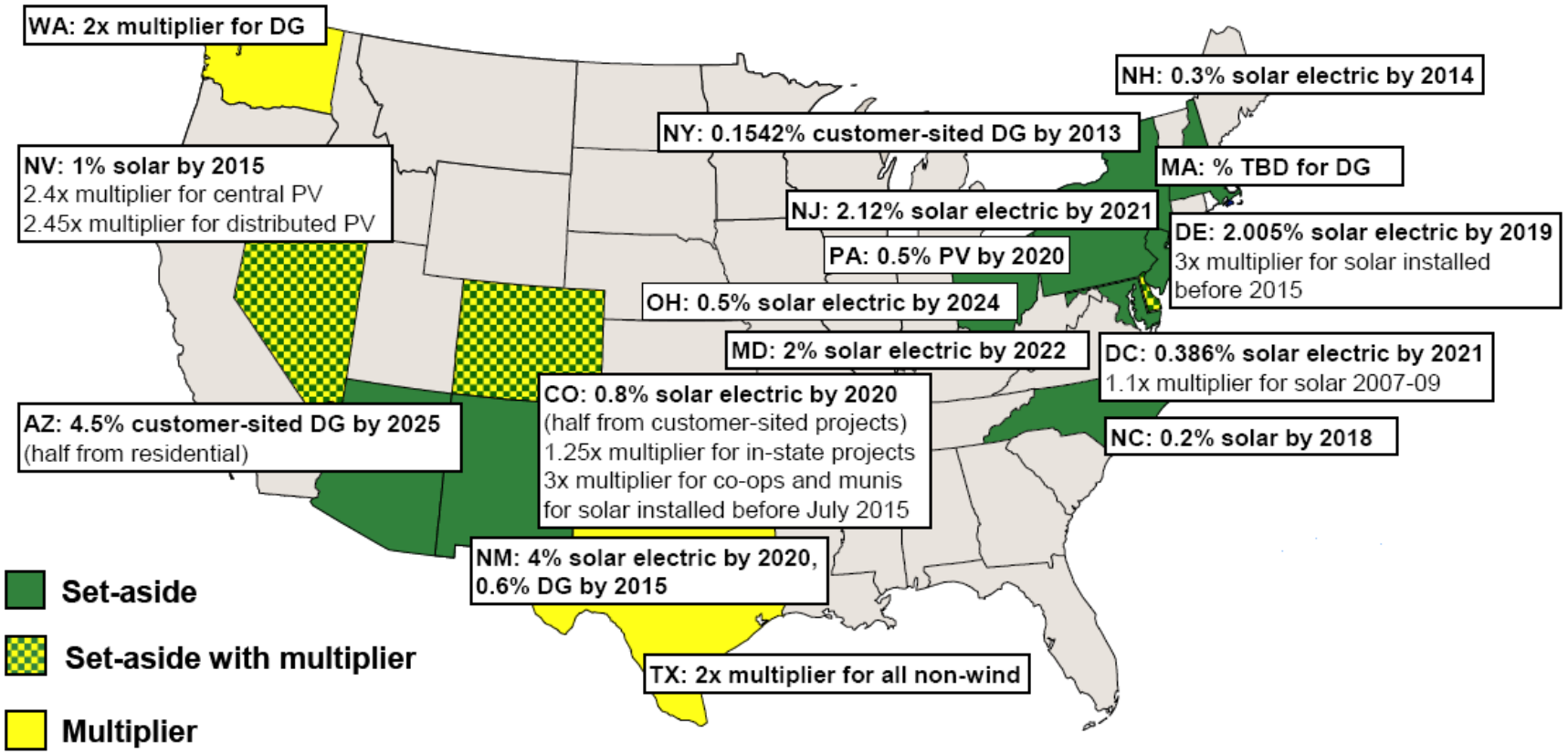
Source: R. Wiser, LBNL (2008), DSIRE

- **Florida recently passed legislation requiring RPS targets to be set next year**
- **California has set a goal of 33% by the end of 2020**

Current solar/DG set-asides and multipliers

13 states and D.C. now have solar/DG set-asides, with 2 more states providing multipliers for DG (WA) and all non-wind (TX)

- There is momentum for solar/DG set-asides; of the 13 states with such policies, 7 states enacted their policies in 2007-2008 (DE, MA, MD, NH, NM, NC and OH)

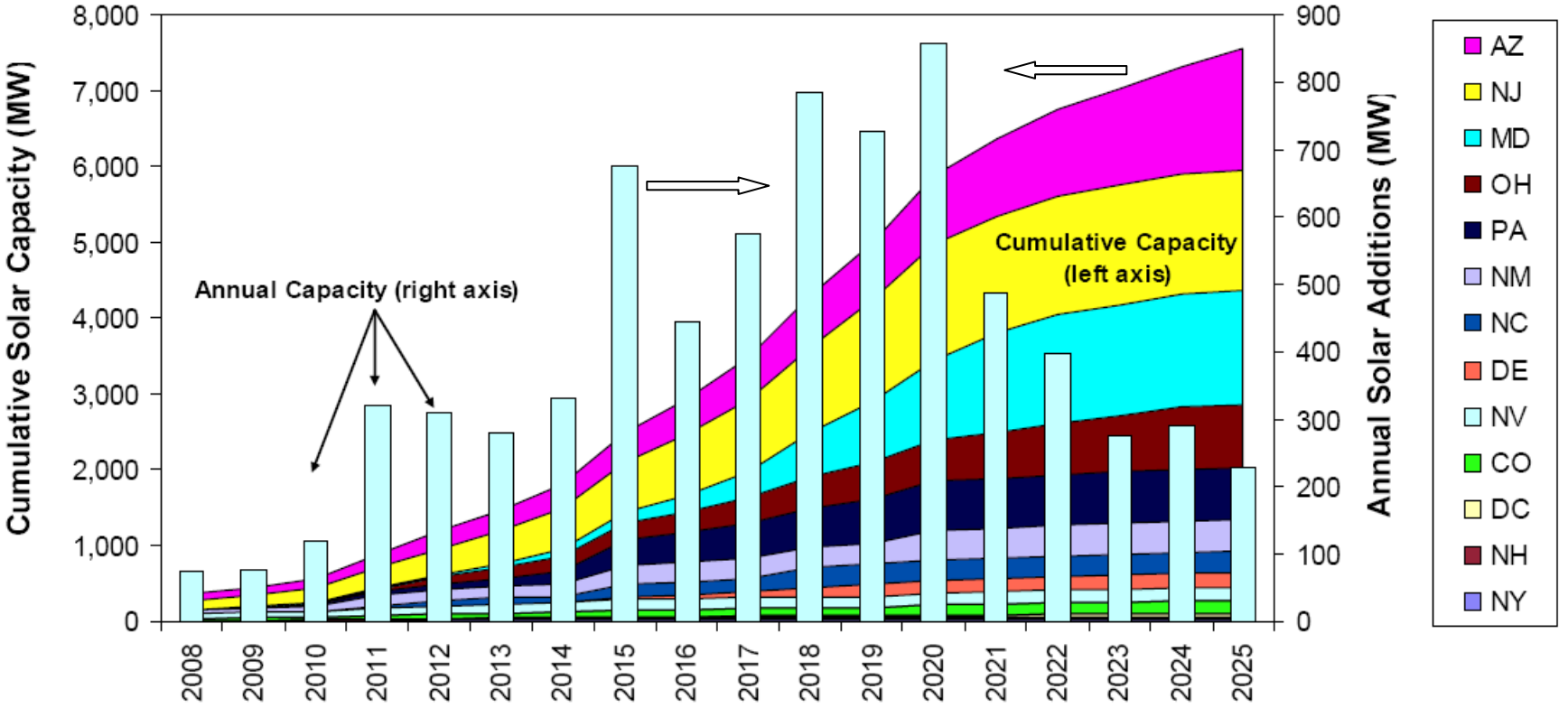


Source: R. Wiser, LBNL (2008), DSIRE

Required solar capacity additions to meet mandated solar/DG set-asides

Based on the 12 states and D.C. with defined solar/DG set-asides (MA is TBD), approximately 2,500 MW of cumulative installations is needed by 2015 and 7,500 MW by 2025

- If California is included, an extra 3,000 MW of cumulative installations will be added by 2017 based on the goals of the California Solar Initiative



Source: R. Wiser, LBNL (2008), DSIRE

California Solar Initiative (CSI)

Signed into law in August 2006, CSI provides up to $3.35 billion in incentives through 2016 with the goal of 3 GW installed capacity by 2017

- $2.167 billion for all systems except new homes in the IOU territories (Pacific Gas & Electric, Southern California Edison and San Diego Gas & Electric)
- $400 million for new homes in the IOU territories
- $784 million for all systems outside of the IOU territories

Systems over 50kW receive a performance based incentive (PBI), a bonus for each kWh produced over five years

- PBI starts at $0.39/kWh and declines to $0.03/kWh as statewide solar capacity increases; depends on IOU territory and type (residential or non-residential)

Systems under 50kW can receive a PBI or elect to take the expected performance based buydown (EPBB), a rebate adjusted to the expected system performance

- EPBB starts at $2.50/Wac and declines to $0.20/Wac as statewide solar capacity increases; depends on IOU territory and type (residential or non-residential)

Current PBI and EPBB offered (varies by IOU territory)

		EPBB Payments (per Watt)			PBI Payments (per kWh)		
Step	Statewide MW in Step	Residential	Non-Residential		Residential	Non-Residential	
			Commercial	Government/ Non-Profit		Commercial	Government/ Non-Profit
1	50	n/a	n/a	n/a	n/a	n/a	n/a
2	70	$2.50	$2.50	$3.25	$0.39	$0.39	$0.50
3	100	$2.20	$2.20	$2.95	$0.34	$0.34	$0.46
4	130	$1.90	$1.90	$2.65	$0.26	$0.26	$0.37
5	160	$1.55	$1.55	$2.30	$0.22	$0.22	$0.32
6	190	$1.10	$1.10	$1.85	$0.15	$0.15	$0.26
7	215	$0.65	$0.65	$1.40	$0.09	$0.09	$0.19
8	250	$0.35	$0.35	$1.10	$0.05	$0.05	$0.15
9	285	$0.25	$0.25	$0.90	$0.03	$0.03	$0.12
10	350	$0.20	$0.20	$0.70	$0.03	$0.03	$0.10

Source: http://www.gosolarcalifornia.ca.gov/

New Jersey - Consumer On-site Renewable Energy (CORE) and Solar Renewable Energy Credit (SREC)

New Jersey's CORE program offered rebates for solar systems

- Between May 2001 and August 2007, New Jersey paid an average of $4.30/W in rebates for 40MW of installed capacity; a total cost of over $170 million
- The state had not anticipated such a high level of interest, and by early 2007, rebate applications exhausted the program's funding through 2008
- In December 2007, the New Jersey Board of Public Utilities (BPU) decided to freeze CORE in April 2008

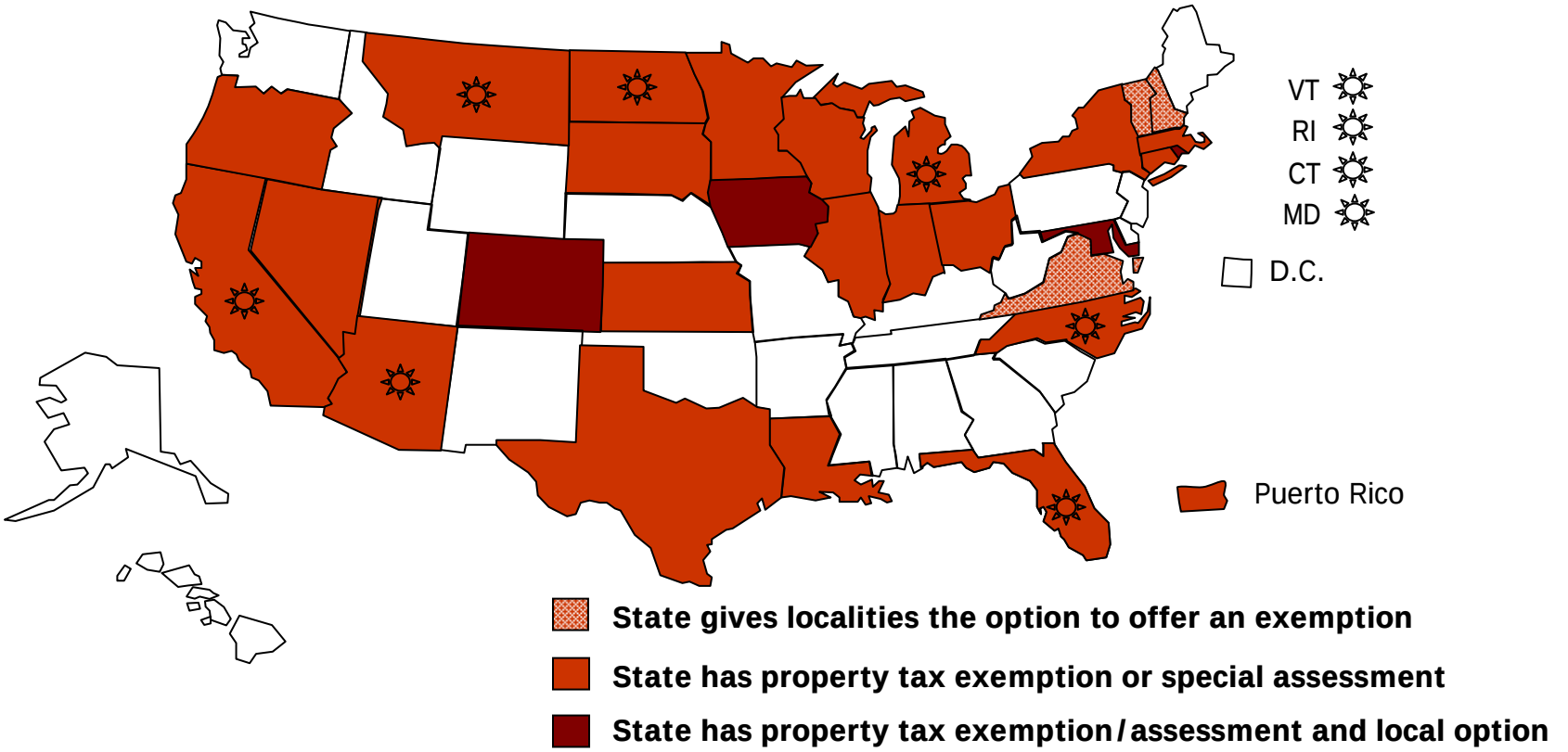
New Jersey is transitioning to the solar renewable energy credit (SREC) program, began as a pilot program in April 2007

- Provides a tariff for solar based on the market value of SRECs, which are used to meet compliance with New Jersey's solar set-asides
- SRECs have been trading at an average value of over $200/MWh during the past year
- The SREC program will improve as a solar incentive if the state's Solar Alternative Compliance Payments (SACPs) are increased from $300/MWh to $700/MWh in 2009, as was proposed by the BPU

Property Tax Exemptions

28 states and Puerto Rico and now provide solar installations with property tax exemptions or give local authorities the option to do so

- 11 of these states (marked with a ☼) have enacted or expanded their property tax exemptions for solar installations since 2003
- The DOE funds the DSIRE database to make information on property tax exemptions more transparent to potential users



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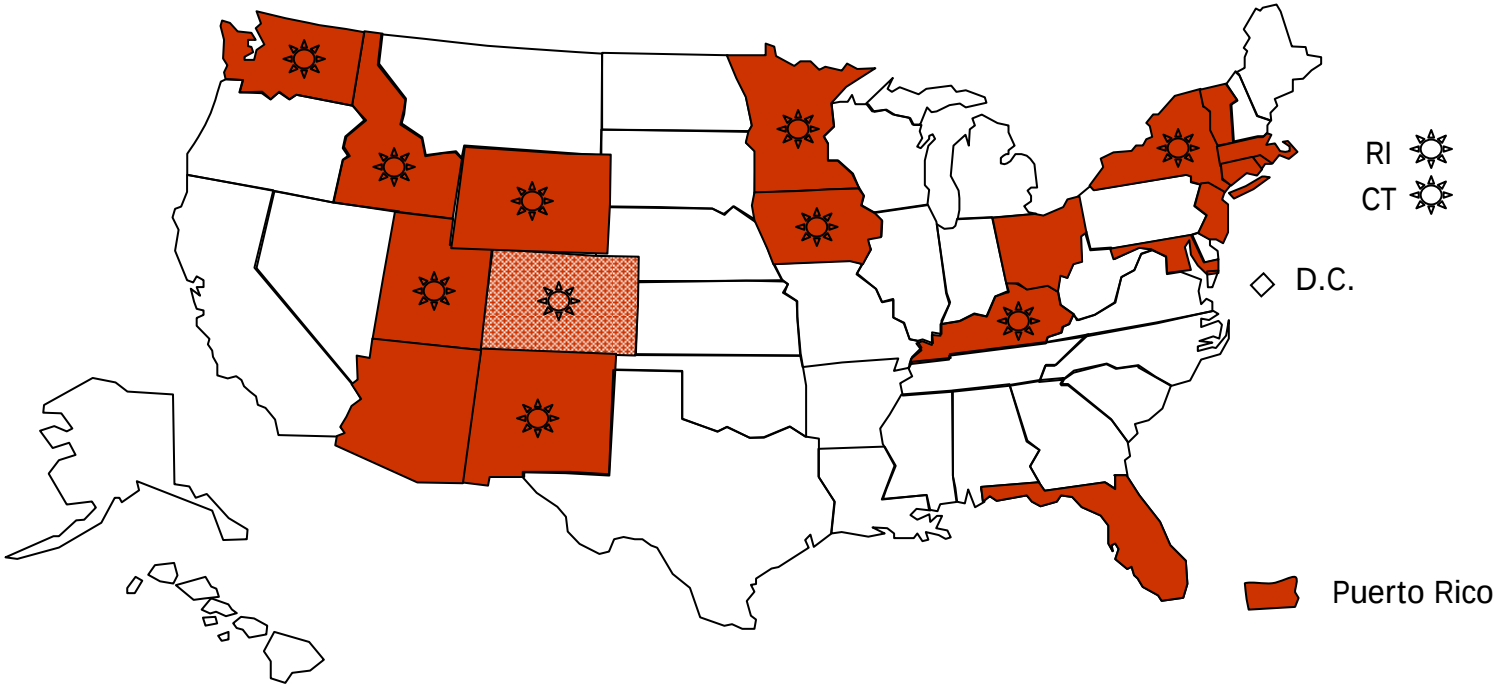
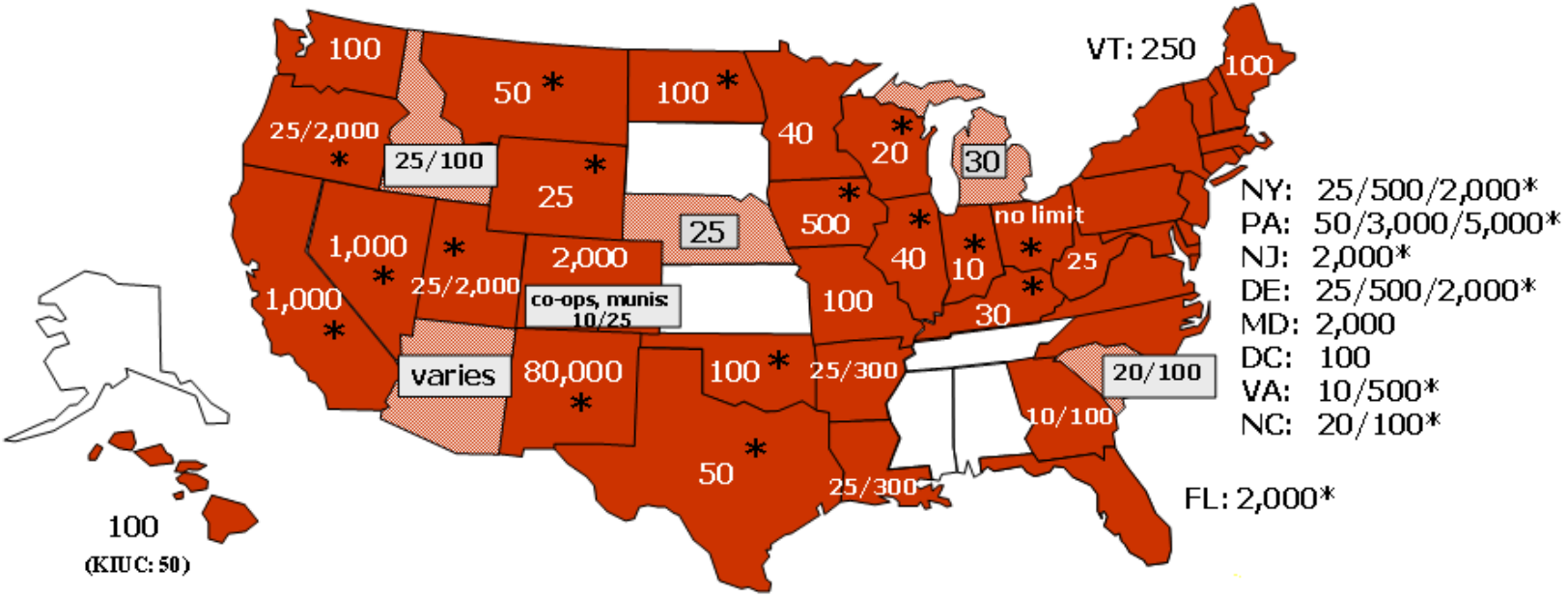


Source: DSIRE

Net Metering

44 states and D.C. now allow for net metering, whether state-wide, for certain types of utilities or offered voluntarily by individual utilities

- Other significant differences in net metering policies include caps on total enrollment or system size, valuation of excess generation and whether third-party owners (solar PPA providers) may net meter
- The DOE partners with the Interstate Renewable Energy Council (IREC) to provide assistance to state policymakers on best practices for net metering and lessons learned from other states



State-wide net metering for all utility types

* State-wide net metering for certain utility types only (e.g., investor-owned utilities)

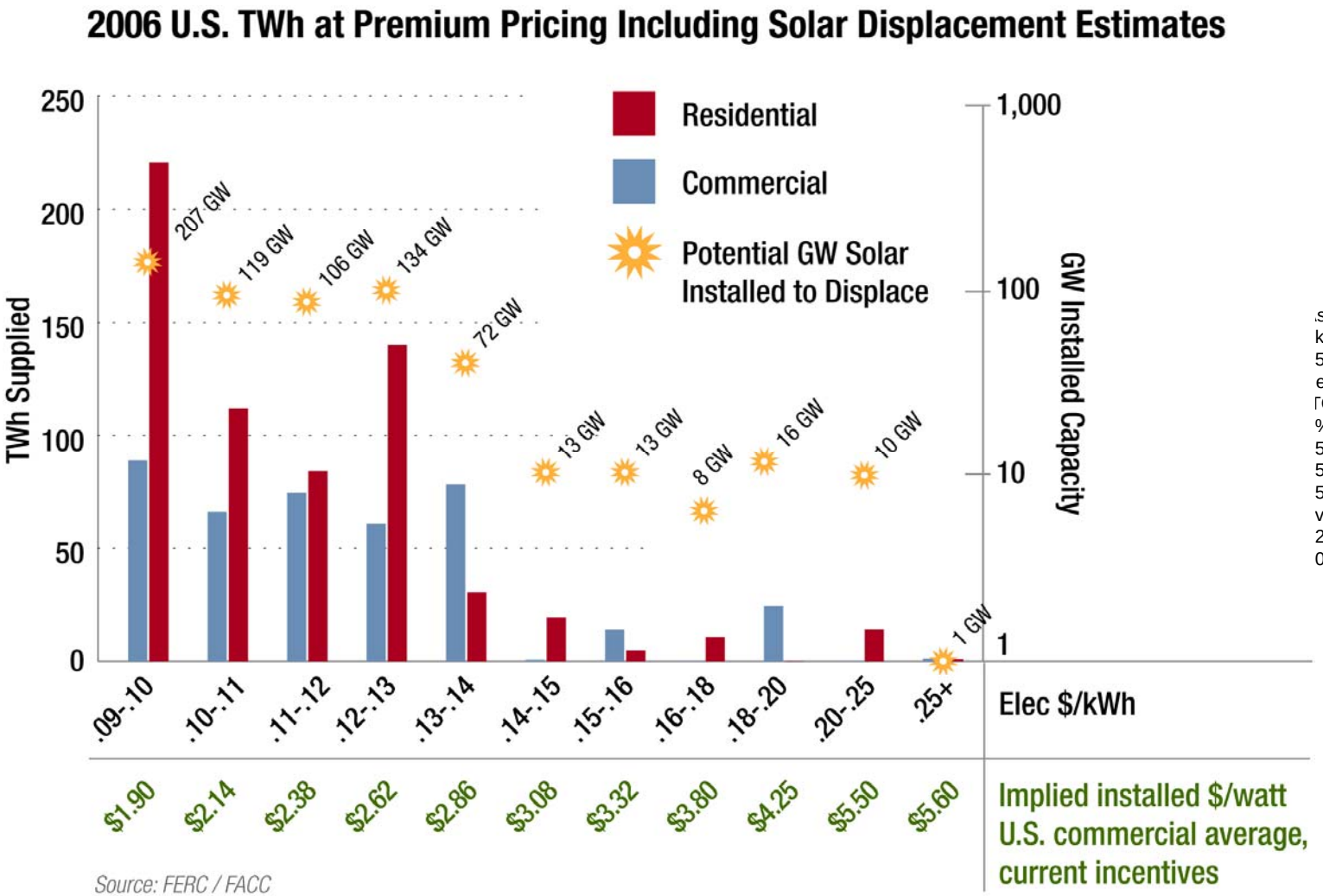
Net metering offered voluntarily by one or more individual utilities

Source: DSIRE

(Note: Numbers indicate individual system size limit in kilowatts (kW). Some states' limits vary by customer type, technology and/or system application. For complete details, see www.dsireusa.org.)

While short-term over-supply may exist, U.S., demand is highly elastic and could take up any drop in system prices

- 40% of U.S. electricity or 1,000 TWh sold for > $0.10/kWh in 2006



ssumptions:
kw installed produces
500 kWh/year
ederal incentives (30%
TC & MACRS)
% interest rate
5 year term
5% tax rate
5.5% capacity factor (US
verage)
2% AC/DC conversion
0% BOS derate factor

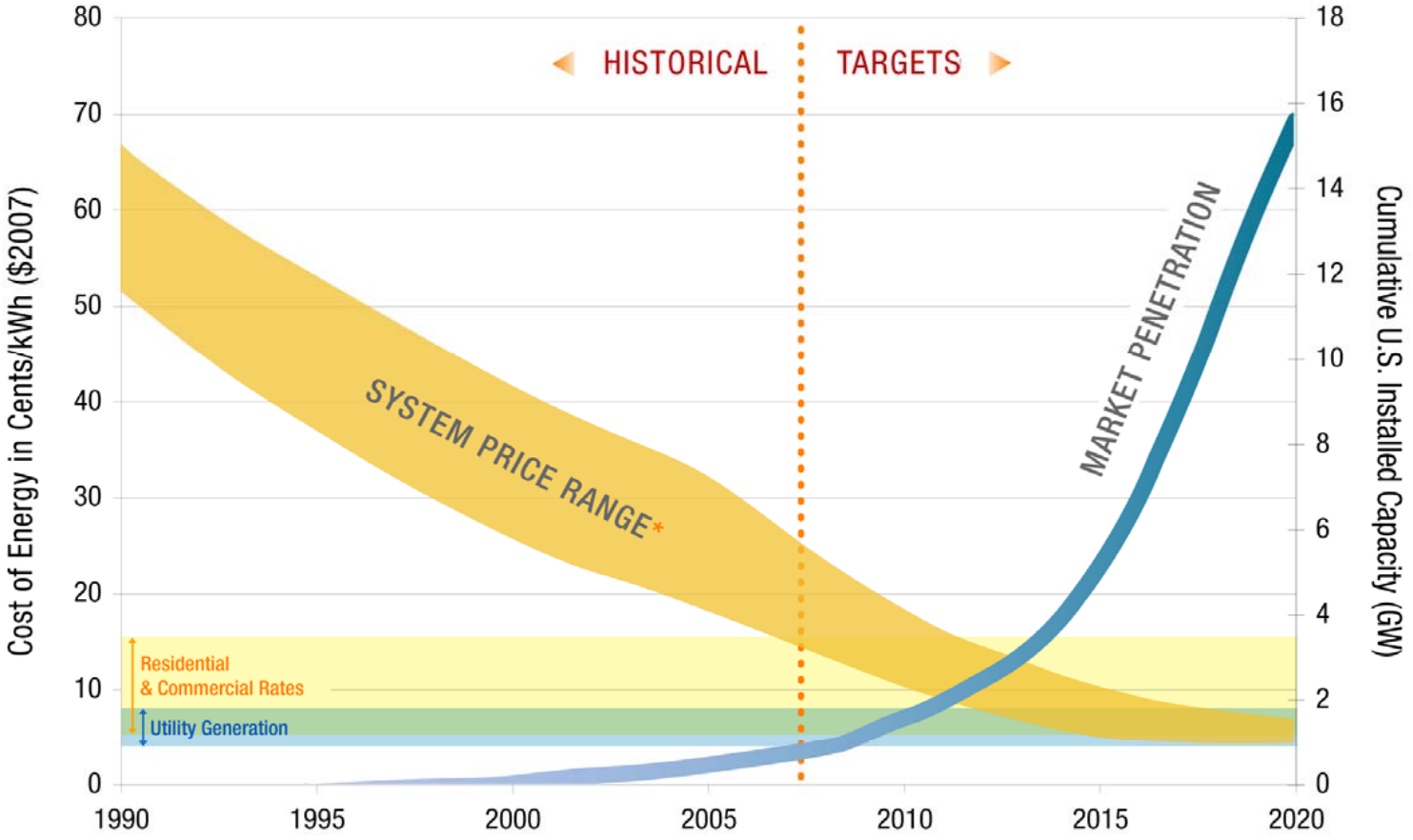
Agenda

- US Solar Program Overview
- Solar Glass Requirements
- Market Dynamics
- Potential Follow-On Federal Solar Incentives

Potential follow-on Federal solar incentives

- Investment Tax Credits
  - Refundable (back and forward)
  - Transferable
  - Use on tax-exempt property
  - Boost for US manufactured equipment
- “Green” Revolving Fund/Infrastructure Bank
  - Expansion of current Loan Guarantee Program
- Economic Stimulus (H.R. 7110)
  - Increased R&D Funding
  - Green Schools
  - Grid modernization
- Removal of current 10-year limit on Federal PPA’s
- National interconnection and net metering standards
- National Renewable Portfolio Standard

The goal of the SAI is to reduce solar electricity to 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

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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The DOE Loan Guarantee Program can provide critical capital for scale-up of PV technologies

Loan guarantees for projects that:

- Avoid, reduce or sequester anthropogenic emissions of greenhouse gases or air pollutants
- Employ new or significantly improved technologies
- Can be deployed commercially
- Provide a reasonable prospect for repayment
- Are sited in the U.S. or its territories, but may have foreign investors or project sponsors

FY2008 Loan Guarantee Authority
$38.5 billion (Expires by end of FY2009) **Applications due by February 28, 2009**
Breakdown
$10.0 billion for energy efficiency, renewable energy and advanced transmission and distribution technologies
$18.5 billion for advanced nuclear power facilities
$2.0 billion for “front end” nuclear fuel cycle facilities
$6.0 billion for coal based power generation, industrial gasification and carbon capture and sequestration
$2.0 billion for advanced coal gasification

DOE's FOA terms give participating companies proprietary rights to practice IP developed under these awards

- Patent Rights
  - Small, domestic businesses and nonprofits take title to subject inventions under the Bayh-Dole Act, (35 USC 200), subject to Gov't retained rights:
    - U.S. Manufacturing Preference
    - March-in rights
      - If recipient is not expected to achieve practical application of the subject invention;
      - If necessary to alleviate health or safety needs which are not reasonably satisfied by the Recipient, assignee, or their licensees;
      - If action is necessary to meet requirements for public use;
      - If recipient is in breach of U.S. manufacturing preference requirements.
    - Government-Purpose License
  - Gov't takes title when awardee is a large business or foreign entity under 48 USC 5908
    - Waivers may be granted under 10 CFR 784
    - U.S. Manufacturing Preference, March-In Rights and Government-Purpose License same as for small businesses
- Data Rights
  - DOE has statutes requiring wide dissemination of data first produced under awards
  - 5-year data protection is granted under EPACT, Hydrogen Future Act.
  - Awardee's proprietary data is protected.