SunShot
U.S. Department of Energy



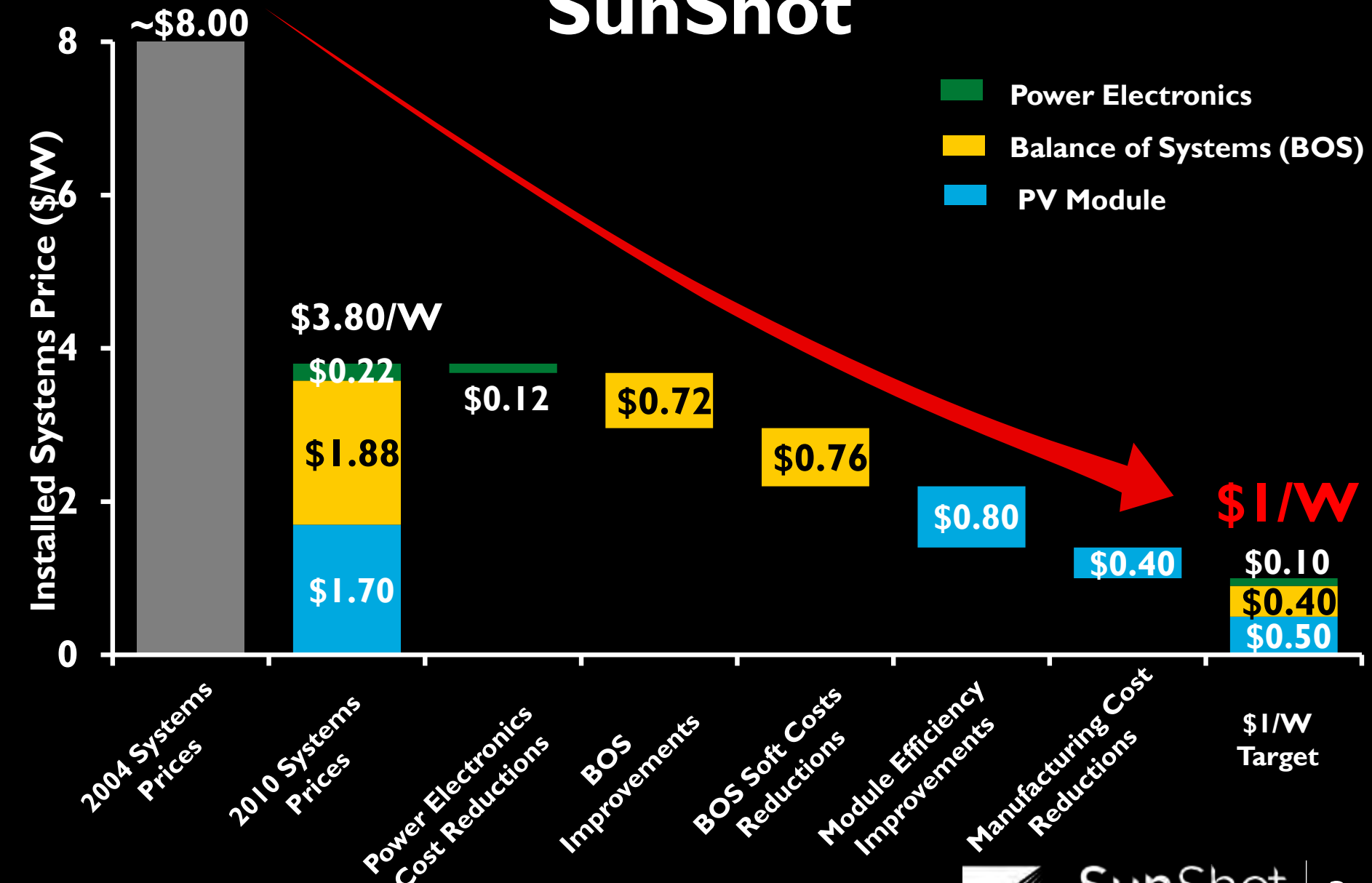
Revitalizing American Competitiveness in Solar Technologies

The SunShot Team

Fundamental Premise for SunShot…

- Subsidy-free solar electricity
- 75% cost reduction by end of the decade
- 5-6c/kWh at utility-scale
- Global Competitiveness

SunShot



Estimates made in 2010 for Utility Scale PV plants

Phase Transition in the Industry

	2010	2011
Q4 c-Si Module Spot ASP	$1.68/W	$1.03/W
US Market Share	6%	~4%
US Deployment	0.9 GW	1.6 GW
China Market Share	51%	~56%
China Deployment	0.5GW	2.0GW

Sources: Module Spot price, UBS investor reports; US/China Deployment, EPIA, "Global Market Outlook for Photovoltaics until 2015" & "Market Report 2011"; US/China Market Share, 2010: GTM Research, 2011: preliminary estimate derived from data by GTM Research & Citibank investor reports

People : Feds, SETA's, SunShot Fellows

1 January 2011

Feds (HQ+GFO) : 20+11 = 31
Contractors (HQ + GFO) : 20+11=31
Fellows (AAAS) : 1

1 January 2012

Feds (HQ+GFO) : 20+3 = 23
Contractors (HQ + GFO) : 17+3= 20
Fellows (AAAS + SunShot) : 3+3=6

Highlights: 16 new PhDs; 5 MBAs

The SunShot Fellows

Adam Cohen
PhD, Maryland
physics

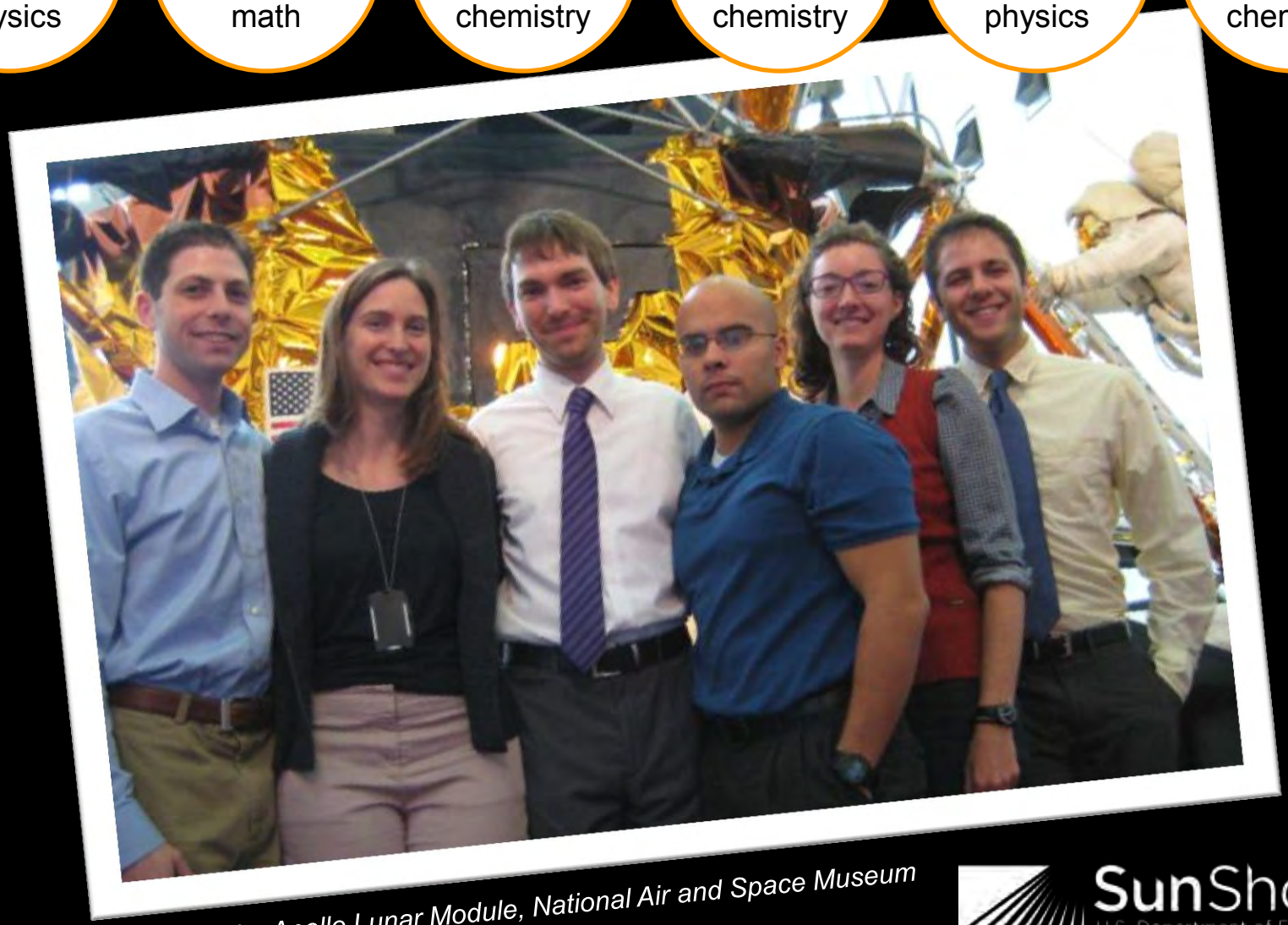
Katherine Crowley
PhD, Rice
math

Lenny Tinker
PhD, Princeton
chemistry

Diogenes Placencia
PhD, Arizona
chemistry

Aimee Bailey
PhD, Imperial
physics

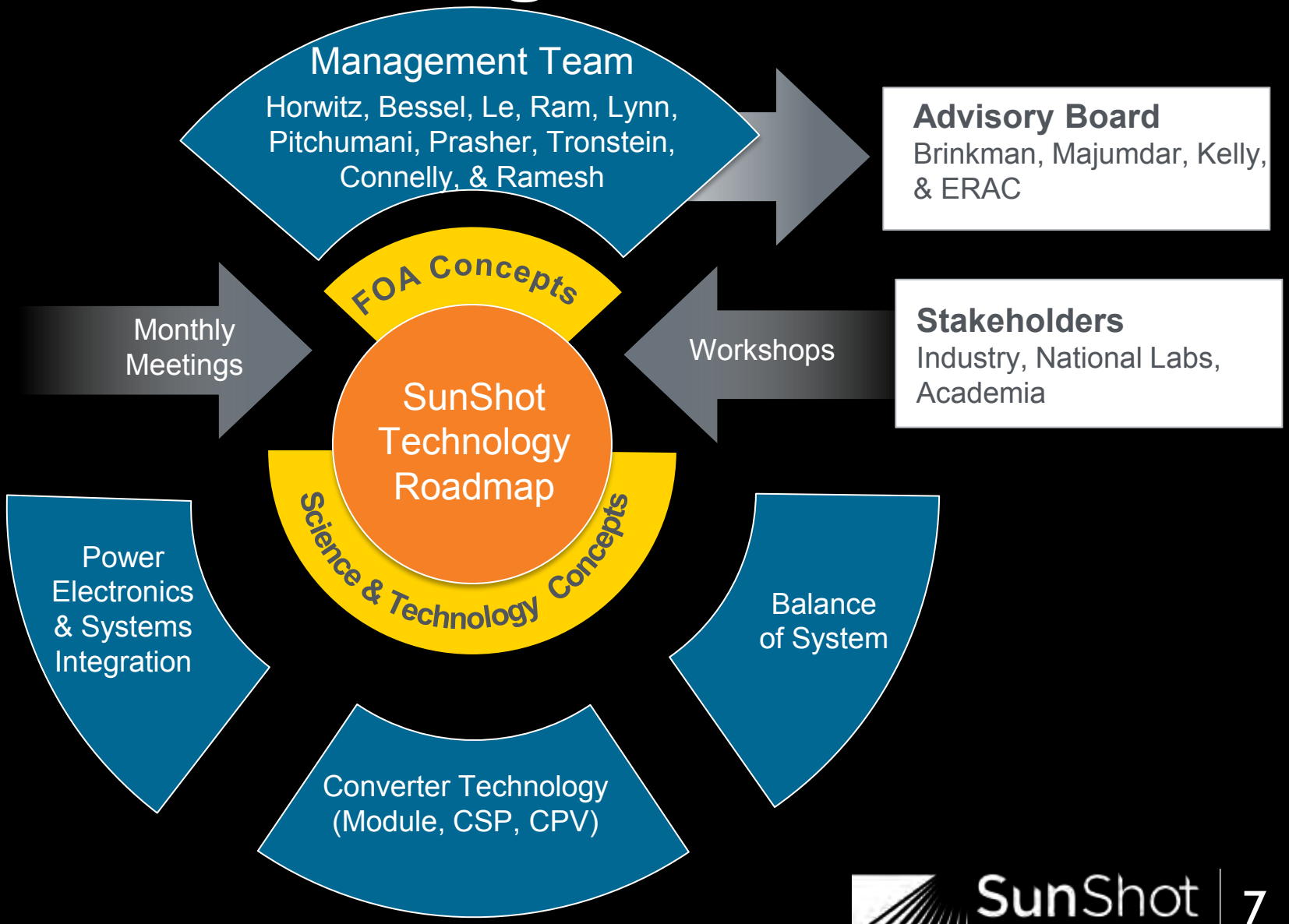
Alex Polizzotti
BS, Pomona
chemistry



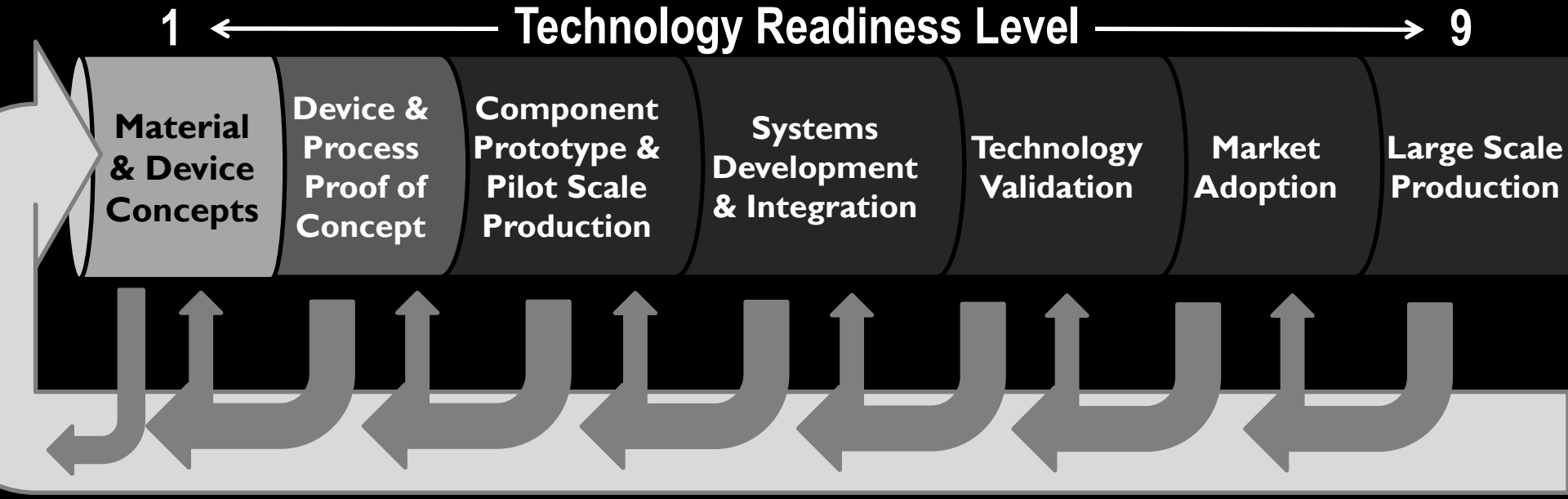
at the Apollo Lunar Module, National Air and Space Museum

SunShot U.S. Department of Energy

SunShot Management Structure



SunShot Program Framework



Basic Energy Sciences

MURI

Next Gen PV

Program to Advance Cell Efficiency (PACE)

SunShot Fellowships

SunShot Incubator

PV Supply Chain

Balance of Systems-Hardware

PV Manufacturing Initiative I

Solar ADEPT - ARPA-E

SEGIS

CSP SunShot FOA

Thermal Storage: HEATS

High Penetration

Incubator – Soft Costs

PVMI II: SUNPATH

Rooftop Solar Challenge

Non-Hardware BOS

Fiscal Responsibility : Use of Prior Year Balances

Source	Fiscal Year	Amount ($,000)	Outcome
NREL	2007-2011	**~19,201**	**PV Validation 2012 Offset**
SNL	2008-2011	**3,988**	**CSP AOP**
GFO	2011	**18,300**	**CSP R&D FOA**
Running Total		**41,489**	

Pre-SunShot

process performance in cumulative weeks

FOA	FOA Announced	Applications Received	Applications Reviewed	Selection	Funding Announced	Total Time
Baseload	7/15/2009	12	30	41	43	**62**
PVMI 1	4/21/2010	7	40	48	50	**73**
HighPen	05/27/2009	8	13	15	17	**48**
SACO	06/24/2009	14	24	41	42	**62**
Supply Chain	10/21/2008	13	21	28	29	**37**
Avg		**10.8**	**25.6**	**34.6**	**36.2**	**56.4**

Phase I : SunShot Initiative FOAs

process performance in cumulative weeks

FOA	FOA Announced	Applications Received	Applications Reviewed	Selection	Funding Announced	Total Time
SEGIS AC	4/8/2011	10	14	17	19	**29**
BOS-X	4/8/2011	8	13	18	19	**29**
FPACE	4/8/2011	10	13	18	19	**28**
Next Gen II	4/8/2011	10	15	18	19	**28**
Soft BOS	05/06/2011	6	10	14	16	**26**
Avg		**8.8**	**13**	**17**	**18.4**	**28**

Example of the Review Process

202 Letters of Intent

96 Encouraged
99 Full Apps

Oral Exam for large $ projects

18 Awards

- 10:1 Down select from Letters of Intent
- Merit Review-each application reviewed by 3 experts
- 10 weeks faster than before

Streamlining Operations

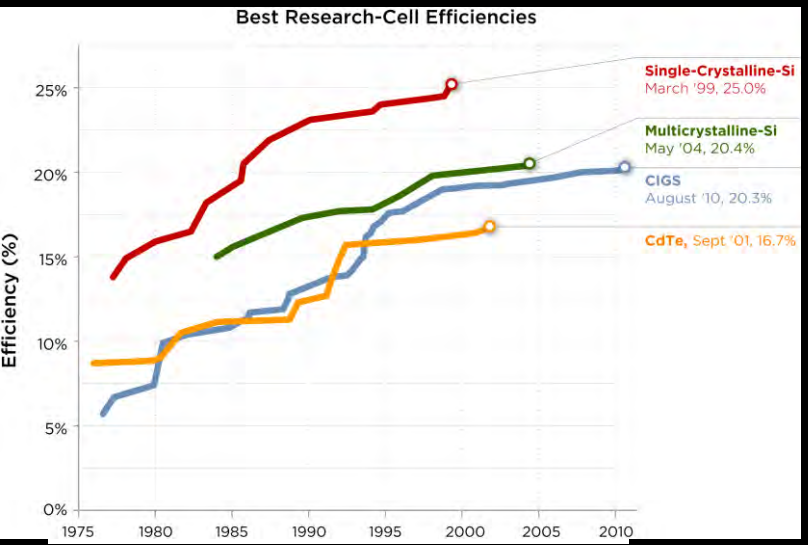
RECOMMENDATION 4-2: The Secretary of Energy should implement the full range of authorities to streamline and focus on energy objectives by:

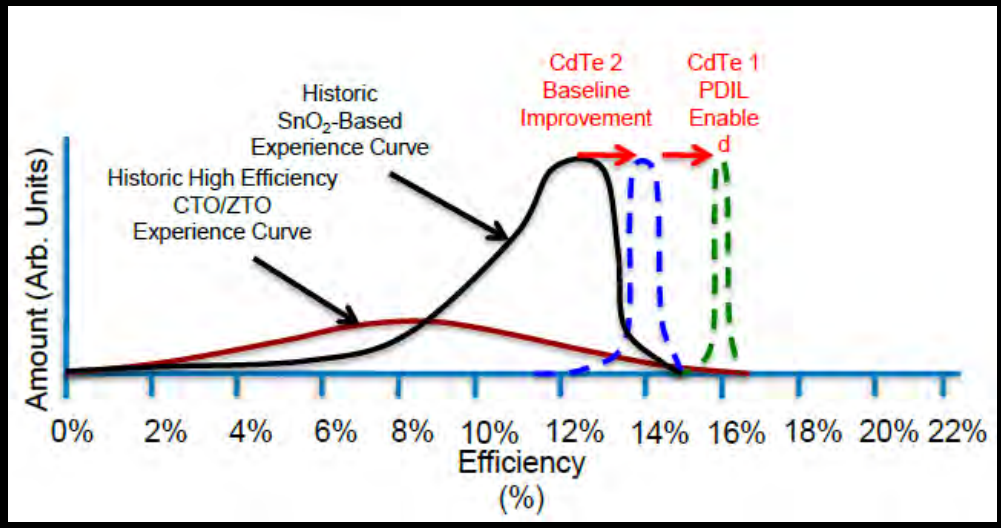
- **extending processes and procedures used successfully in ARPA-E to all DOE energy programs;**

…

PCAST Report Recommendations

CdTe – Getting to 23% Efficiency
CdTe – Prior NREL Research Program
The Michael Jordan Program



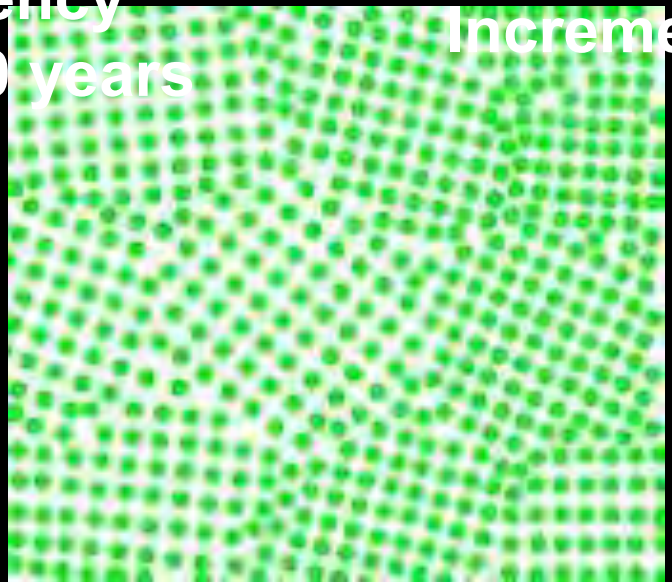


CdTe Cell Efficiency Stagnant for ~10 years

NREL Focus : Incremental improvements

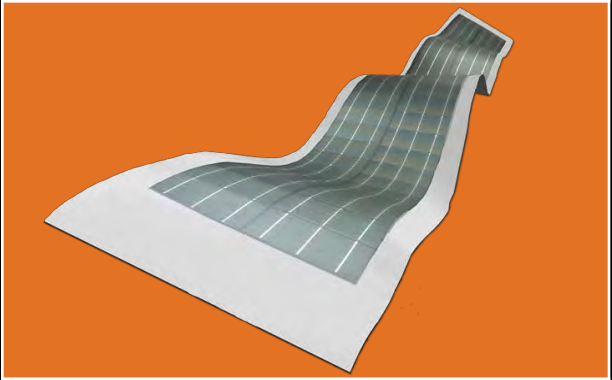
Point Defects- Cd Vacancies

Line Defects : Dislocations



Grain Boundary Control

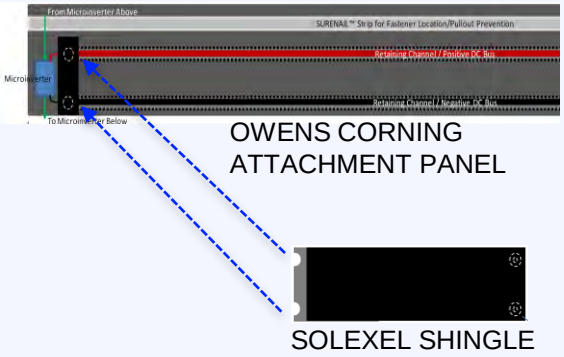
BOS-X :Transformational BIPV



Roofing membranes using CIGS or thin-film c-Si cells

$2M
(Federal Funds)

CARLISLE CONSTRUCTION MATERIALS



Roof shingles utilizing high efficiency, flexible c-Si cells; low cost distributed circuitry at the cell level; integrated micro-inverters

$2.8M
(Federal Funds)

SOLEXEL

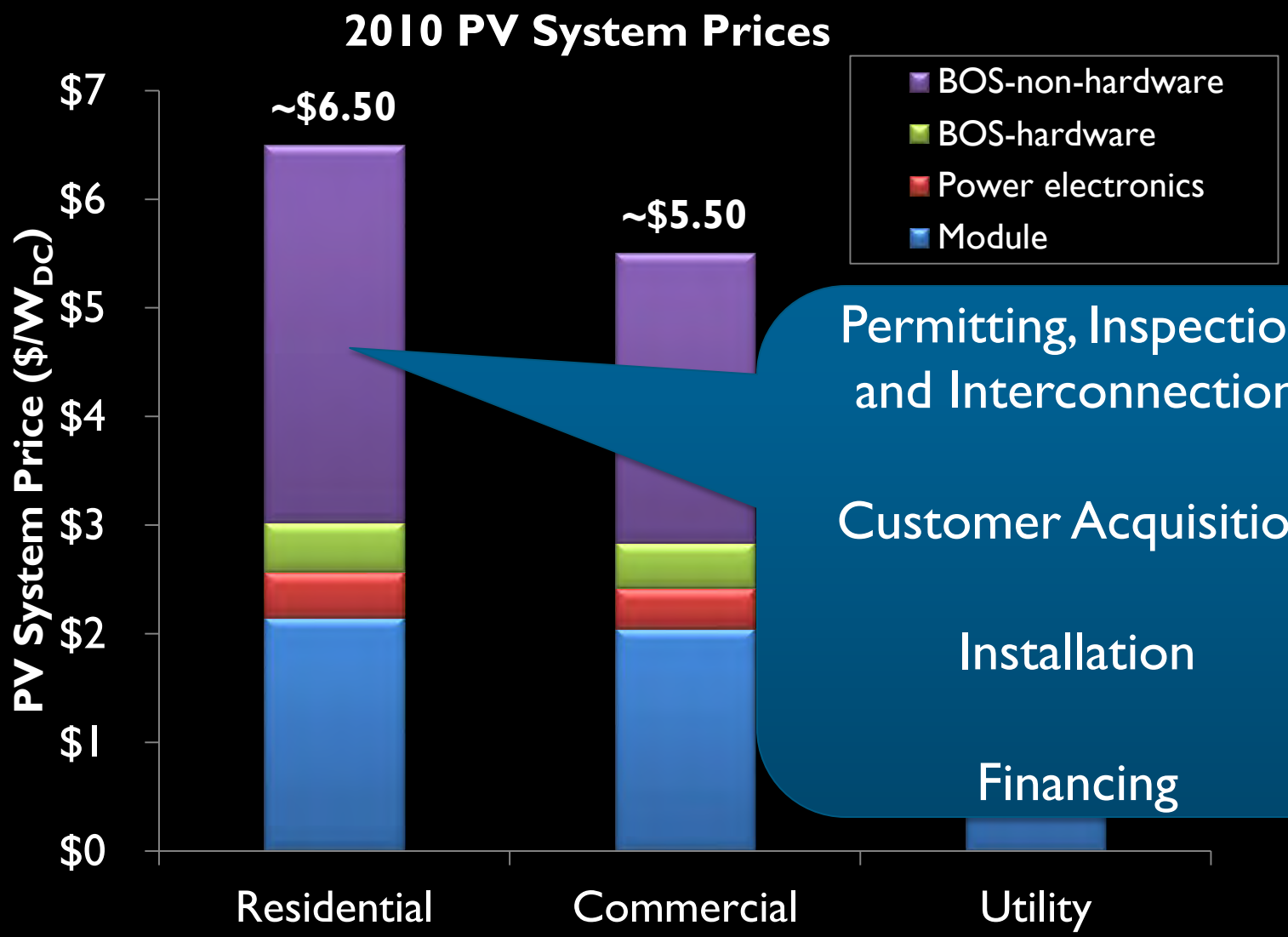
OWENS CORNING

Roof shingles utilizing high efficiency, thin-film GaAs cells; heat management and recovery; integrated power electronics

$2.8M
(Federal Funds)

DOW®

BOS-Soft Costs Will Determine the Future of Solar!!



The Problem is not the same as Hardware R&D

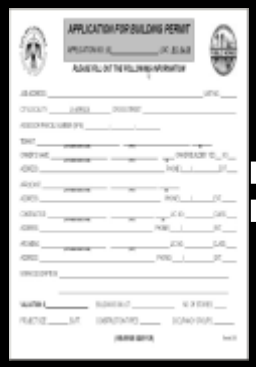
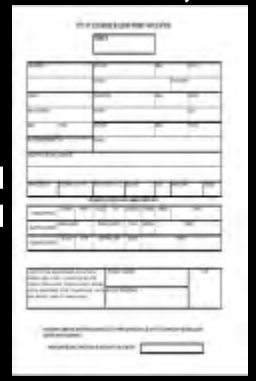
Problem:

- 18,000+ local jurisdictions with authority over *PV permitting requirements, land use codes and zoning ordinances*
- 5,000+ utilities implementing *interconnection standards and net metering programs*
- 50 states developing interconnection standards and net metering rules

CA = NJ | CA ≠ WI | La Mirada, CA ≠ Oceanside, CA

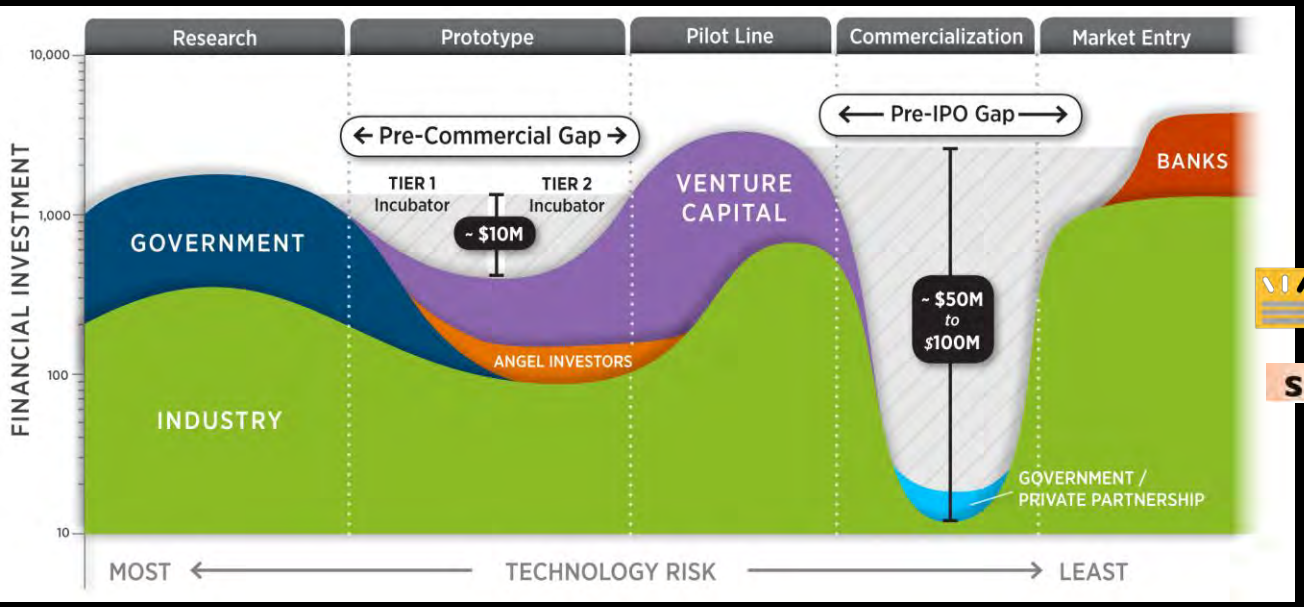




Solution: Rooftop Permitting Challenge

SunShot Incubator :Very Successful!!



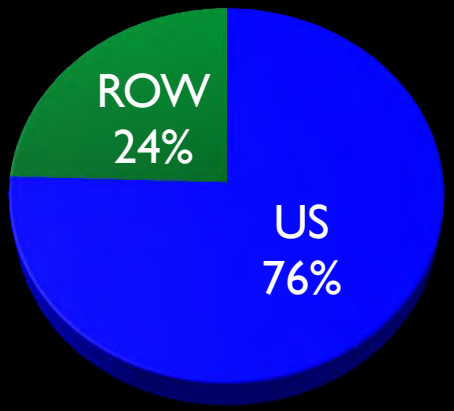
Sample awardees:

- Foster innovation and growth in the domestic PV industry
- Help domestic start-up companies overcome first "Valley of Death"
- Leverage NREL's device expertise and R&D resources
- Strong leveraging of Government investment

Since 2007, $59M in DOE funds have leveraged $1.6 B in private capital

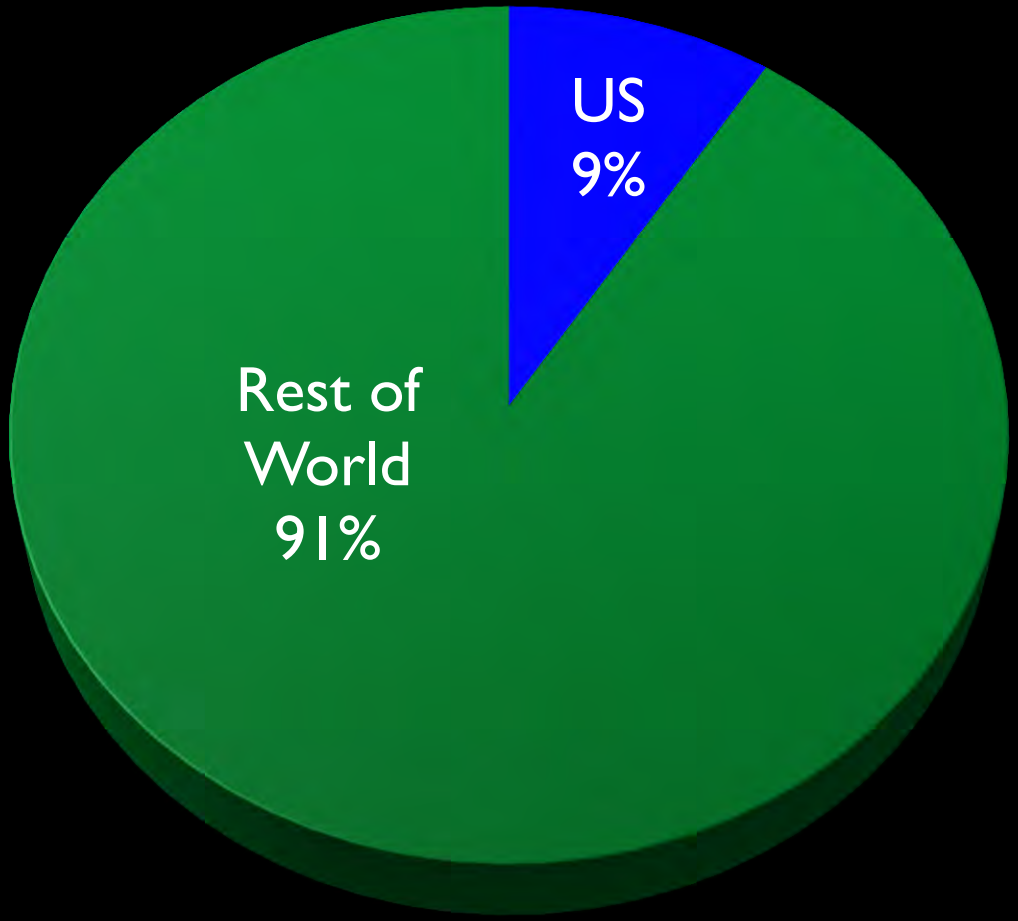
US excels at Innovation – But lags in manufacturing of innovation

VC & PE Investment in Solar (2010)



$2.3B

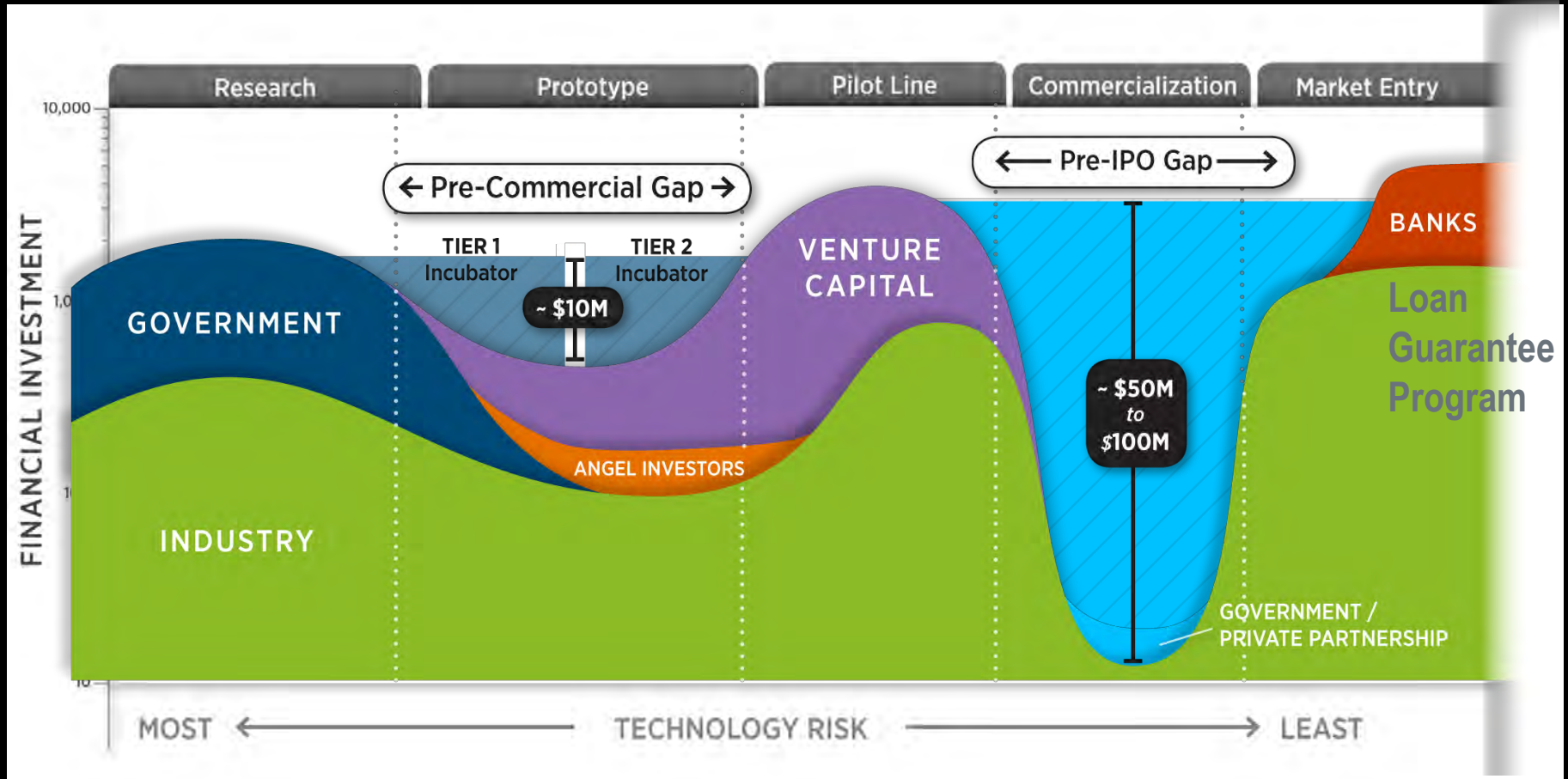
Debt Finance in Solar (2010)



$44B

Source: Bloomberg NEF (12/08, 3/6/09, 4/9/10, 4/16/10, 11/8/10, & 3/16/11)

SUNPATH (Scaling Up Nascent PV AT Home)

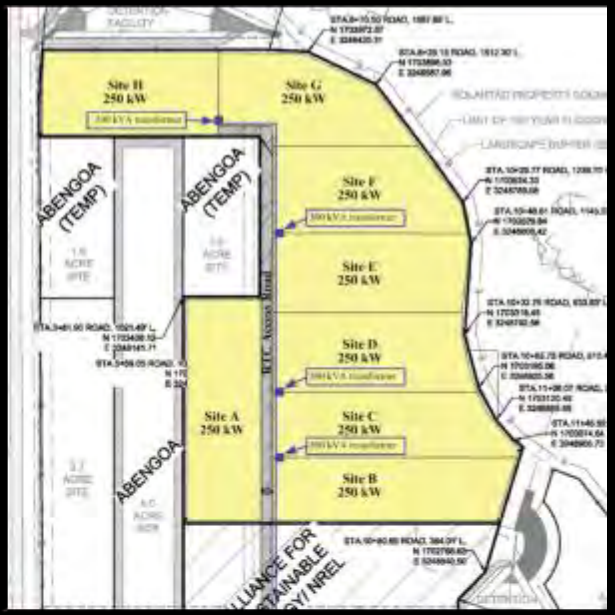


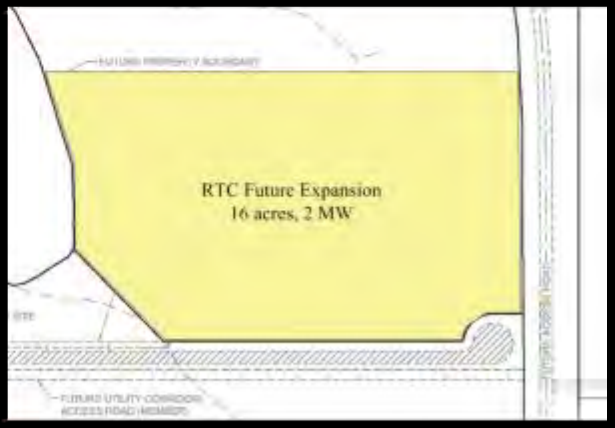
First pilot to first commercial scale manufacturing facility: access to capital for innovative companies; the goal is scaling-up and retaining innovation and jobs

Regional Test Centers : Facilitating Bankability

- **Vision:**
  - 50kW –2 MW systems for 3 years
  - Test in multiple climates
  - Validate performance and reliability

- **Locations:**
  - Albuquerque (Sandia)
  - Denver (SolarTAC – NREL)
  - Orlando (UCF – FSEC)



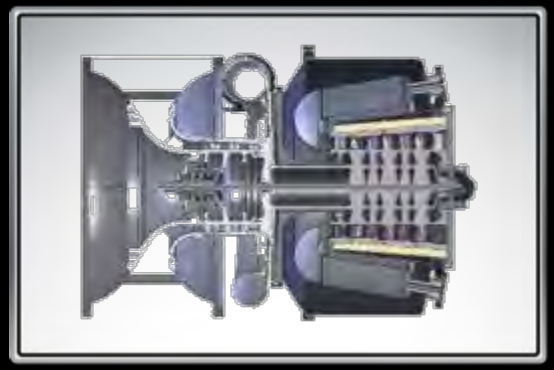


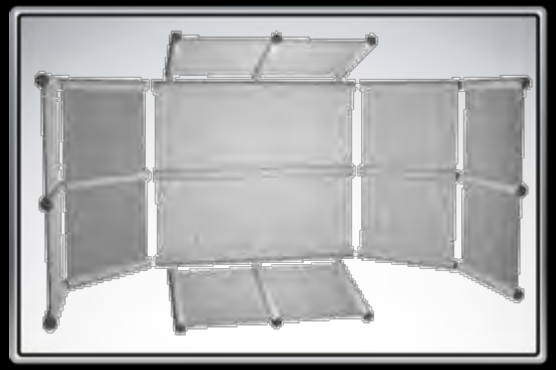
SunShot CSP R&D FOA (FY12)

Objective
Highly disruptive CSP technologies to meet SunShot goal of 6¢/kWh by the end of decade

1. Low-Cost Collectors < $75/m^2 (+manufacturing)
2. High-Temperature Receivers > 650˚C (+ associated hardware)
3. High-Efficiency Power Cycles > 50% (+ associated hardware)
4. Seedling CSP Concepts (early development)

5. Thermal Storage in collaboration with ARPA-E HEATS





Going Forward … Targeting BOS-S

Investing in potentially high-impact solutions, accelerating project timelines and reducing "soft" costs.

	Customer Acquisition	Financing & Contracting	System Design & Engineering	Permitting, Inspection, & Interconnection	Installation	O&M
Permitting/ Inspection Database						
SunShot Incubator						
IT-based approaches						
Utility Engagement						

 Pre-workshop Phase

 Potential Incubator or stand-alone FOA

 Open FOA

 FY12 Project Awarded

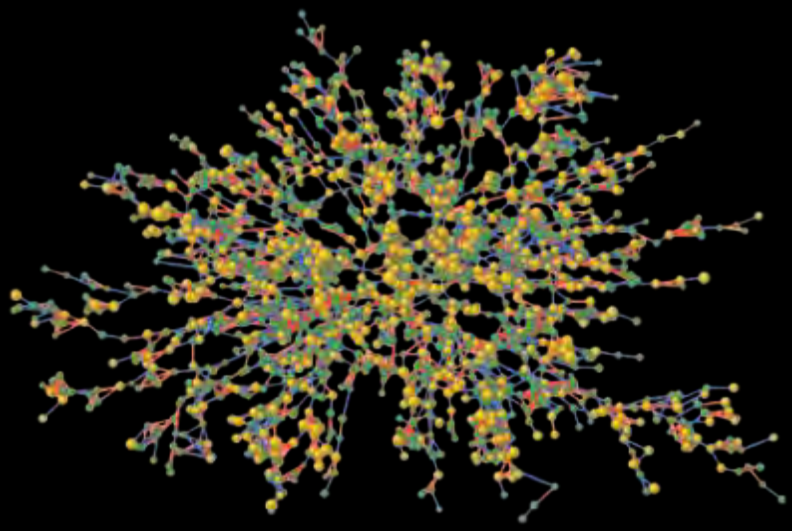
Ad Lucem

Basic R&D for Market Transformation Pathways

Workshop: Feb. 17, 2012, Berkeley, CA

Overview

- Basic R&D incorporating the human aspect of our energy challenges can spur social, economic, and behavioral innovation
- Tools from complexity science allows us to probe such issues



Potential Research Topics

- Information and technology diffusion on social networks
- Mechanisms underlying the rate of technological progress
- Characterizing spatiotemporal adoption patterns
- Effective and efficient communication strategies
- Strengthening feedback processes between adopters and innovators

The spread of obesity in a large social network
N.A. Christakis *et al.*, *N. Engl. J. Med.* **357** (2007)

SunShot U.S. Department of Energy

BRIDGE – Basic Research Integration Development Grant in Energy

Objective:

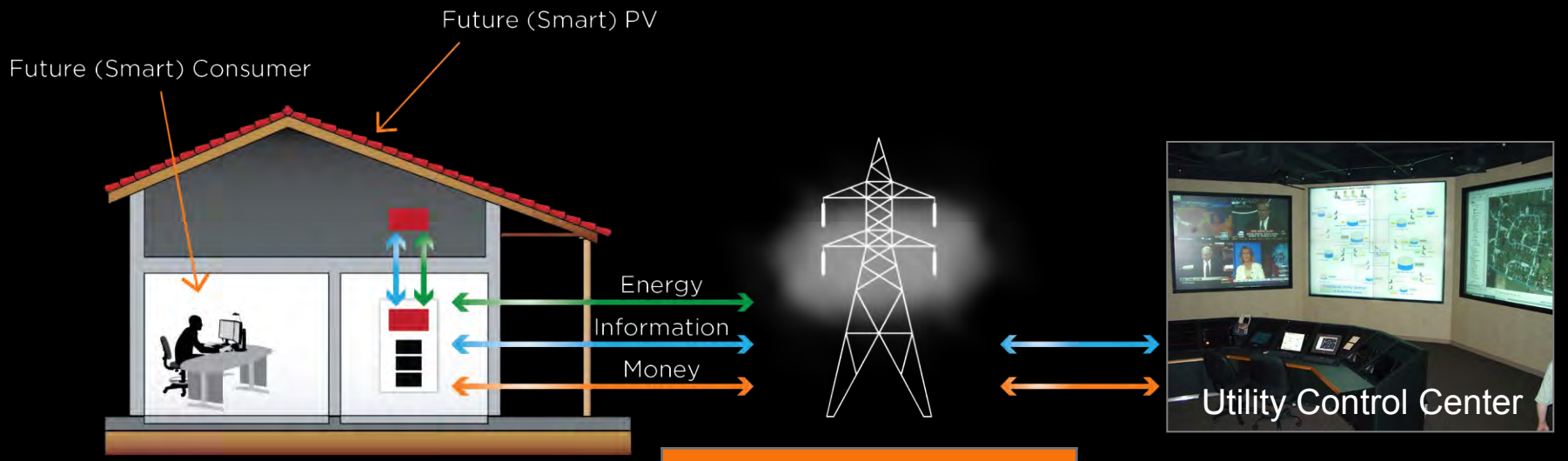
- Connect applied solar researchers with the scientific user facilities/staff

- Two types of FOAs
  - Fund PV research that includes time at the SUF
  - Coordinate with SUFs to conduct a joint FOA

Plug-and-Play

Vision : PV as an Appliance

No permitting Easy installation Seamless grid integration



Future (Smart) Home

- Smart outlet
- Smart circuit
- Smart breaker panel
- Smart appliances
- Home area network (HAN)

Future (Smart) Grid

- Distributed generation
- Two-way power flow
- Communication and control
- Rich energy information and transactions
- Microgrid

Future (Smart) City

- Integrated grid and city planning

GEARED - Grid Engineers for Accelerated Renewable Energy Deployment

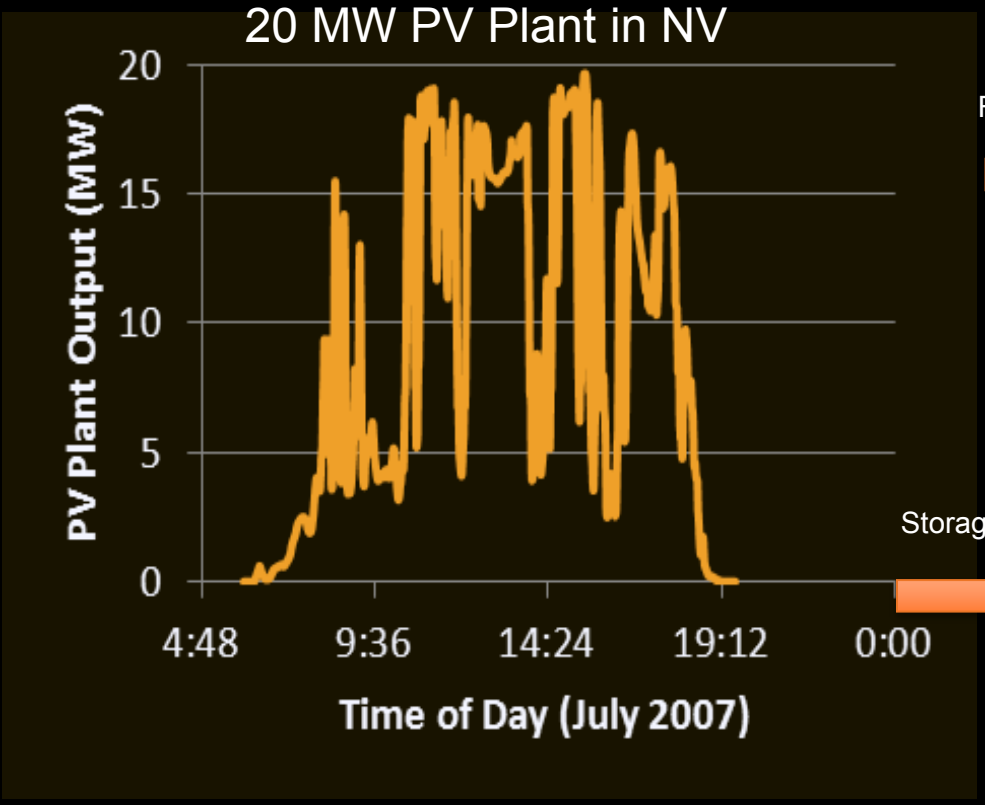
Problem:

- Electric Grid workforce is aging – mass retirements in 5-15 years
- Lack of skilled personnel conflicts with need for a new "smart grid"
- Center for Energy Workforce Development estimates the need for 92,000 new grid workers, including ~**18,000 engineers**

Goal:

- Establish **University programs to train a network of grid engineering STEM professionals** , ready for a 21st century renewable economy

The Solution for PV Variability : Energy Storage

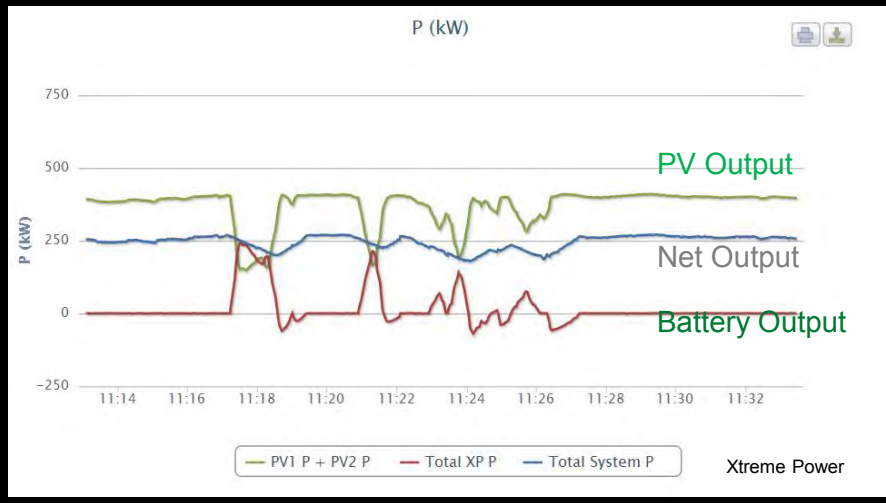


Forecasting

Solar Forecasting Program

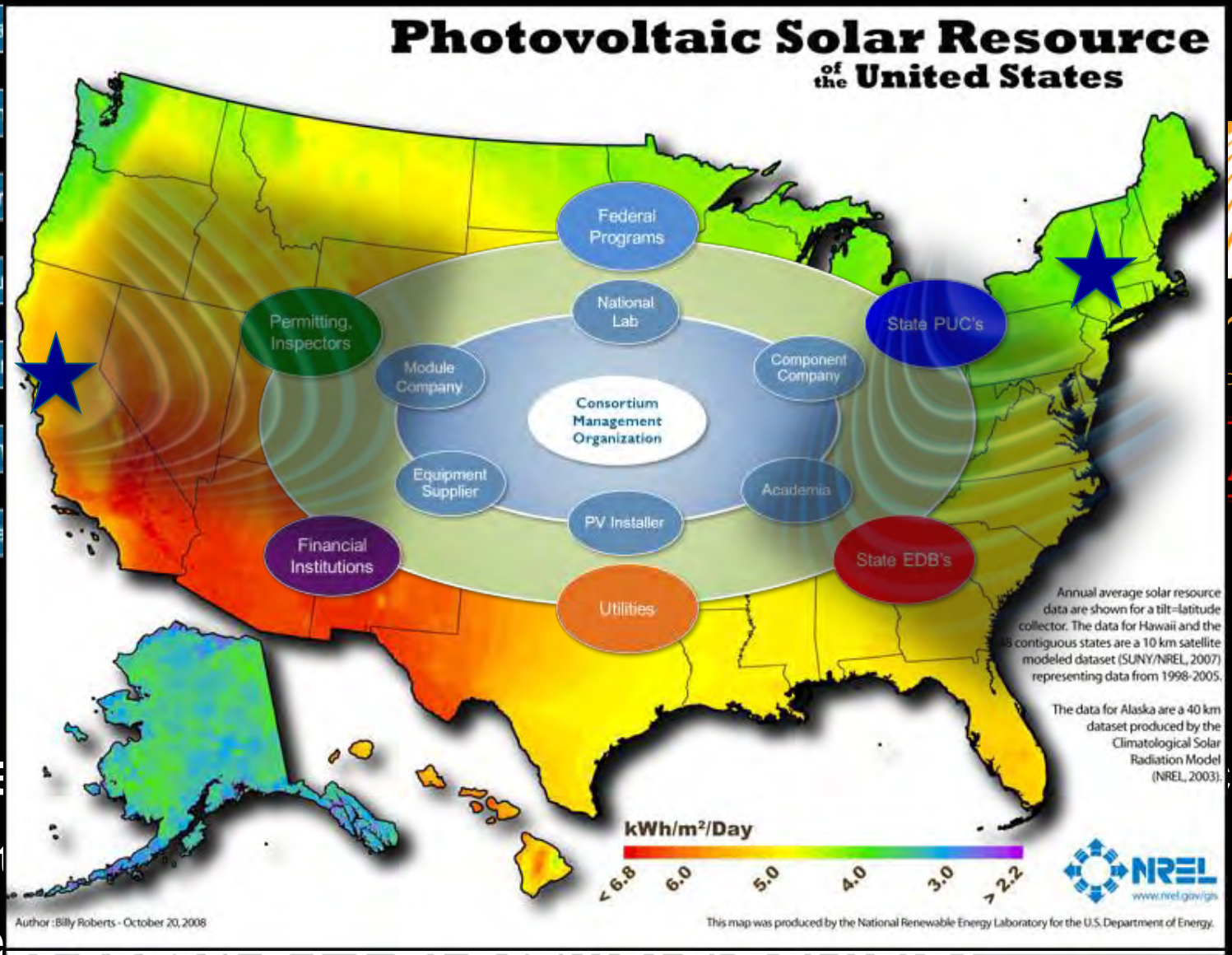
Total Sky Imager allows forecasting 15-30 minutes ahead

Storage



- Initiate lab R&D on Storage, in collaboration with ARPA-E and OE; participate in Storage Hub

Creating a New Solar Eco-System : Hubs



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America has the opportunity to lead the world in clean energy technologies and provide a foundation for our future prosperity.

We remain the most innovative country in the world … but "Invented in America" is not good enough to guarantee our prosperity.

"Invented in America, Made in America, Sold World-wide"