Concentrating Solar Power Program

Ranga Pitchumani

SunShot
U.S. Department of Energy

SunShot Grand Challenge and Peer Review • May 20, 2014 • Anaheim, CA

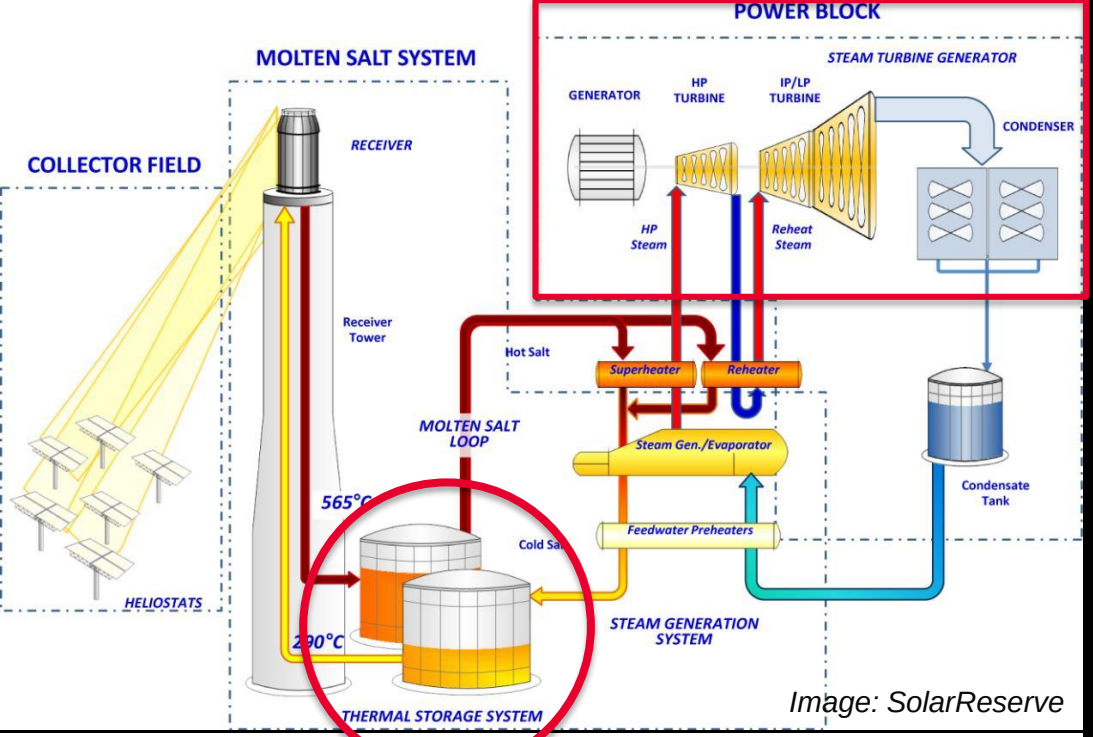
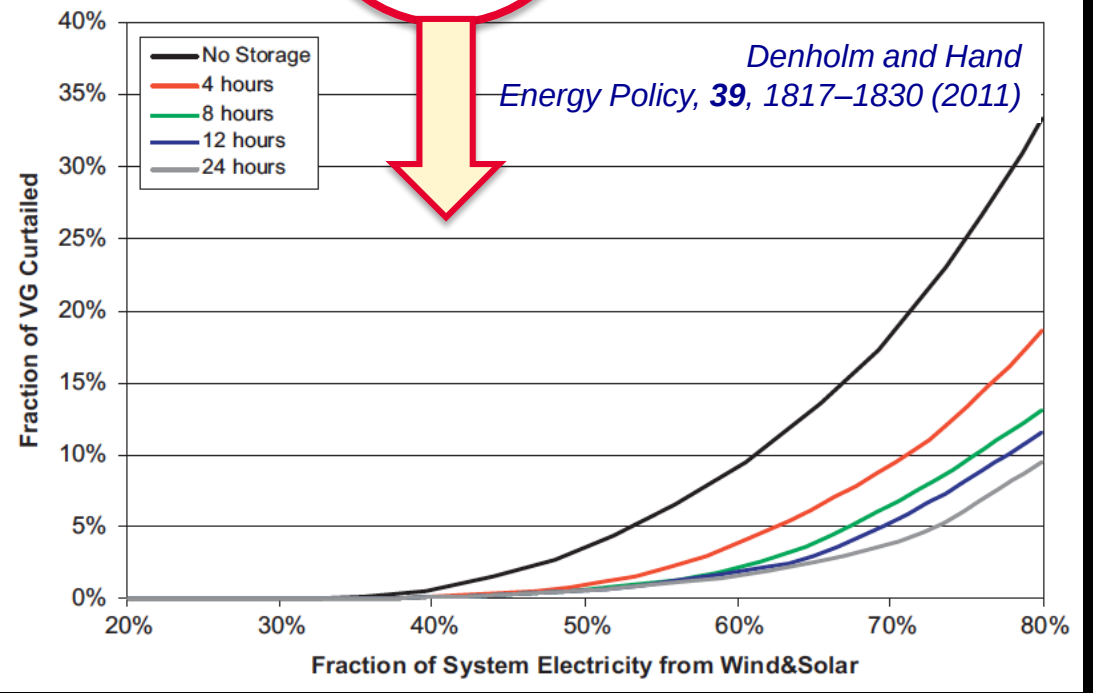


Image: SolarReserve



Thermal Energy Storage

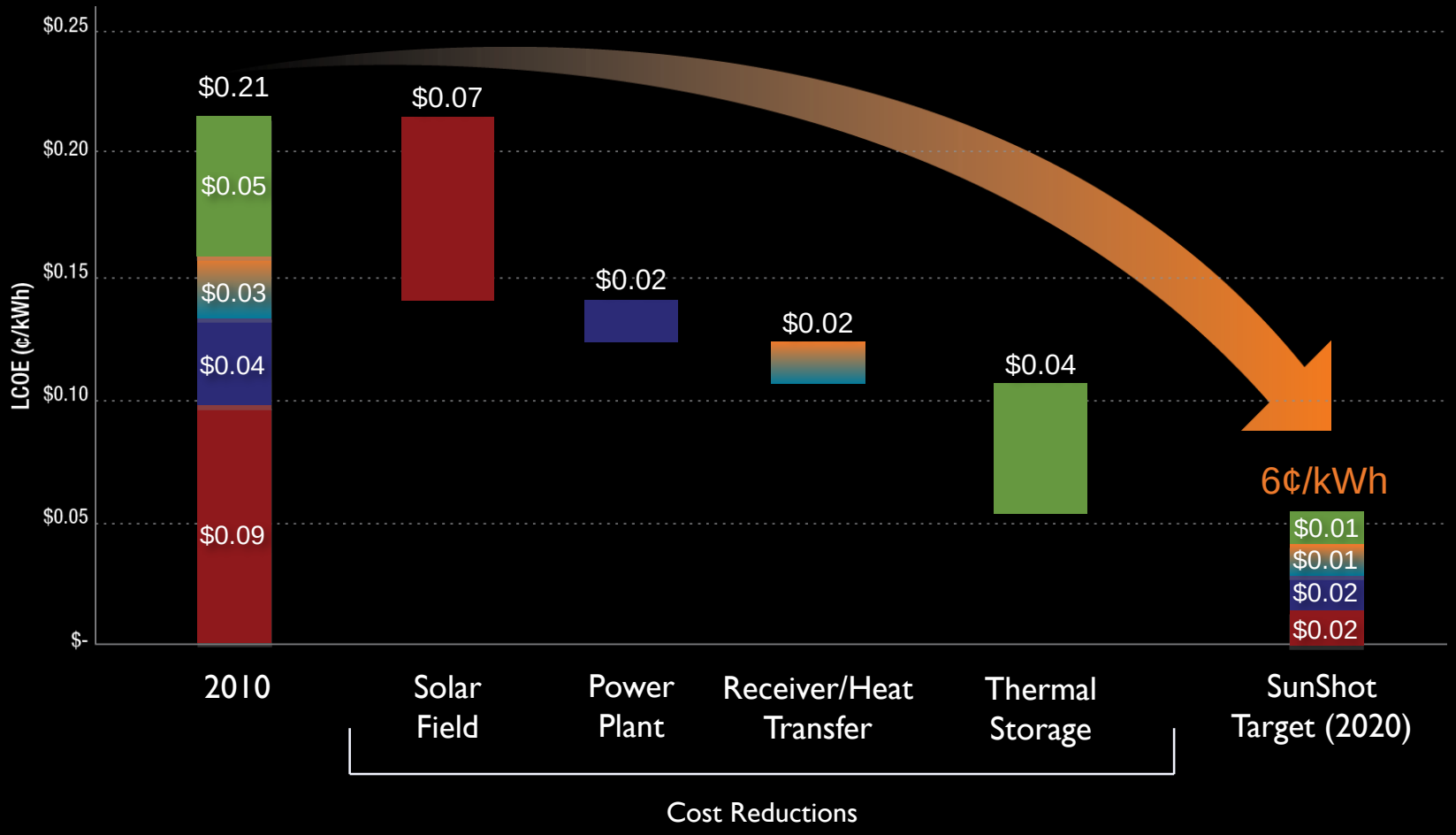
- Inexpensive storage (2010: $27/kWh)
- Provides for several hours of operation even when the sun is not shining
- Provides for greater incorporation of variable generators on the grid

CSP-Fossil Hybrid

- Provides for synergistic hybridization with fossil fuel power plants

CSP is a key enabling technology in the nation's future energy generation mix

SunShot CSP Goal



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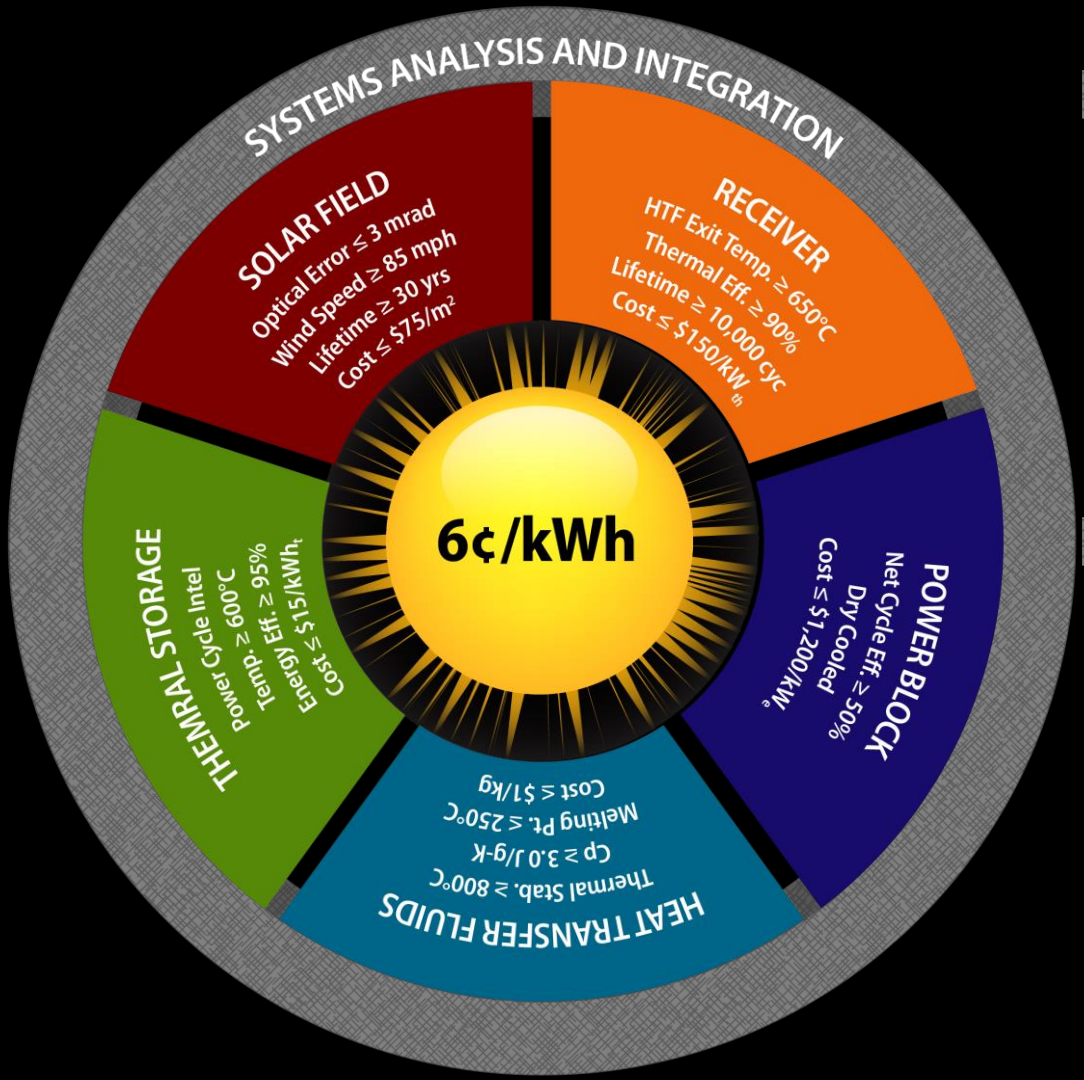
$$\eta = 1 - \frac{T_C}{T_H}$$

Increasing efficiency requires higher temperatures

Technical Targets



Competitive Initiatives

$25M	SolarMat II (2014)
$20M	CSP: ELEMENTS (2014)
$20M	CSP-HIBRED (2013)
$ 8M	PREDICTS (2013)
$15M	SolarMat (2013)
$10M	SunShot MURI (2012)
$30M	National Lab R&D (2012)
$ 5M	BRIDGE (2012)
$56M	SunShot CSP R&D (2012)
$ – M	Incubator/SBIR (Recurring)
$53M	CSP Baseload (2010)
$29M	ARRA (2009)
$27M	Thermal Storage (2008)

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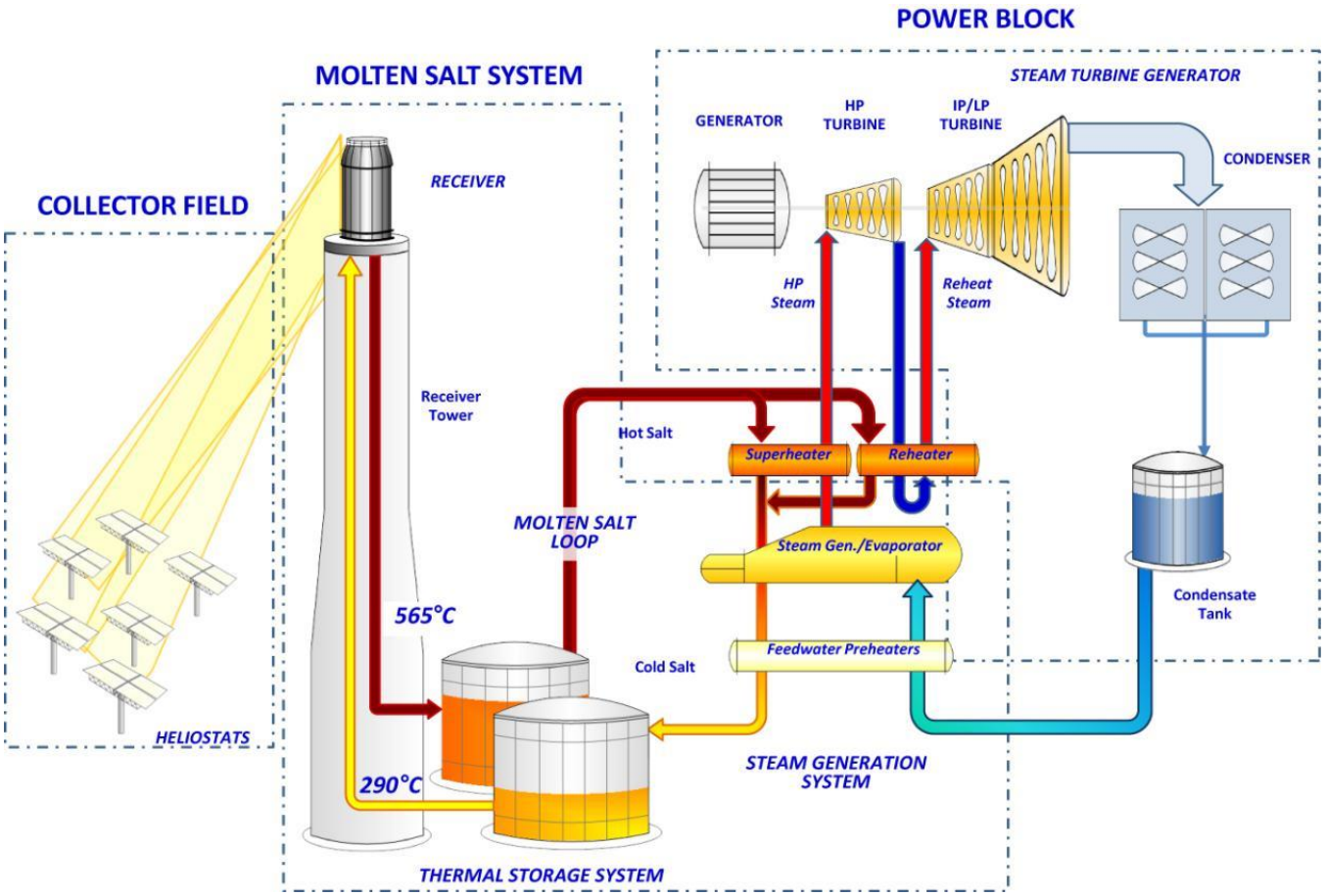

Image: SolarReserve

Collector Field
- Optical Physics
- Structural design and dynamics
- Manufacturing and Automation
- Sensors and control

Receivers
- Optical properties
- Coatings
- High temperature materials
- Chemistry
- Heat Transfer, Fluid Mechanics

TES and HTF
- Chemistry
- High temperature materials
- Materials Science
- Heat Transfer, Fluid Mechanics

Power Block
- High temperature materials
- Turbomachinery
- Chemistry
- Sensors and control

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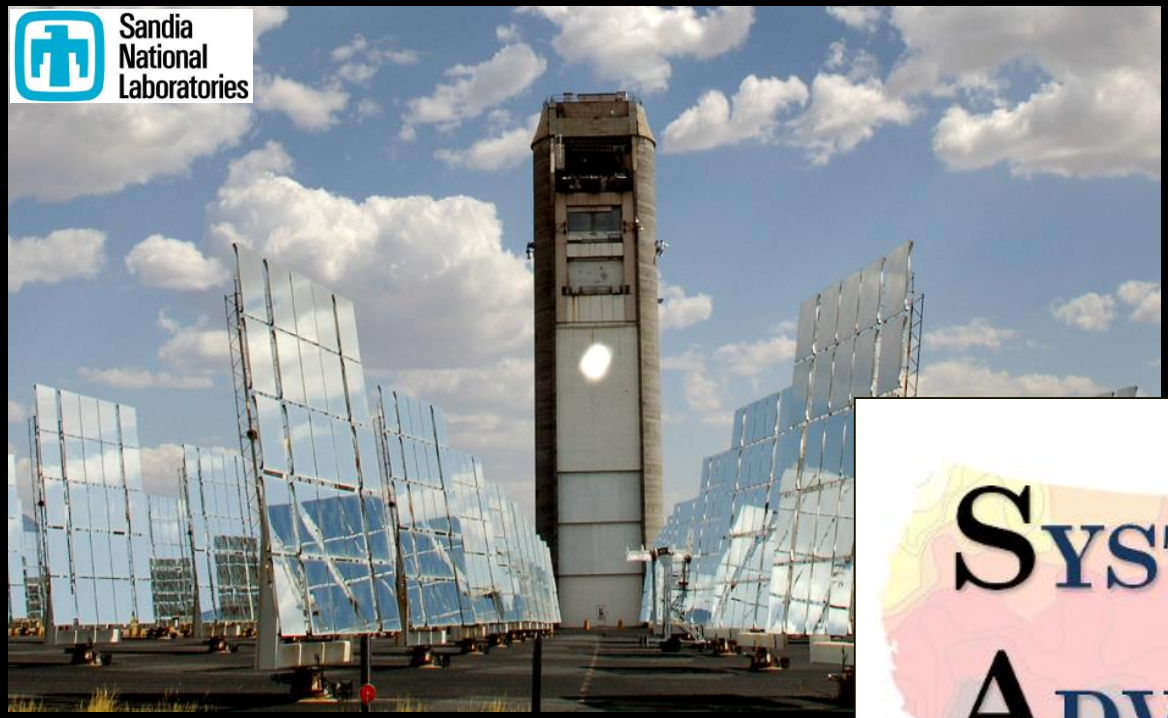
SunShot CSP Core Capabilities



energy.sandia.gov

sam.nrel.gov

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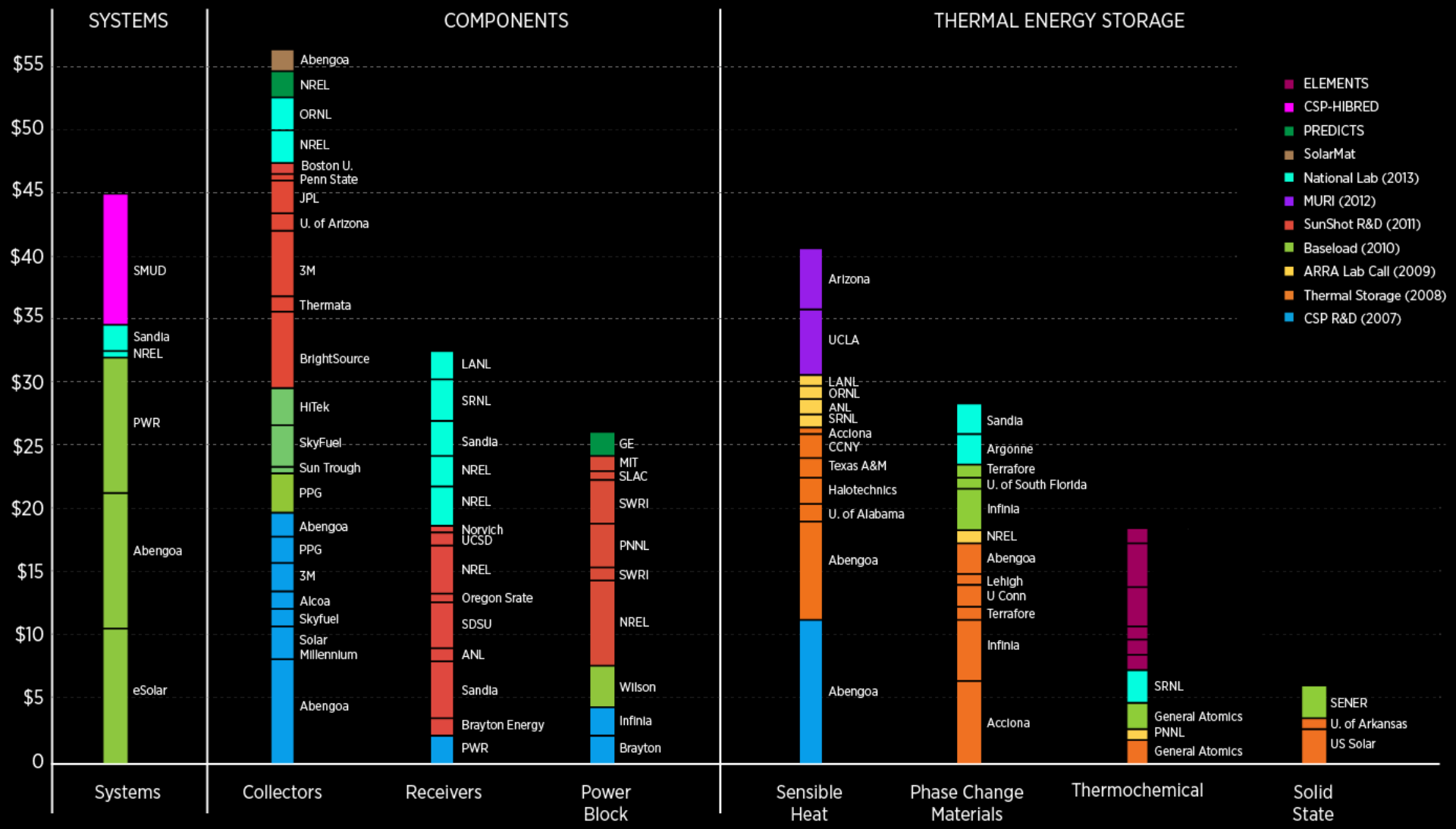
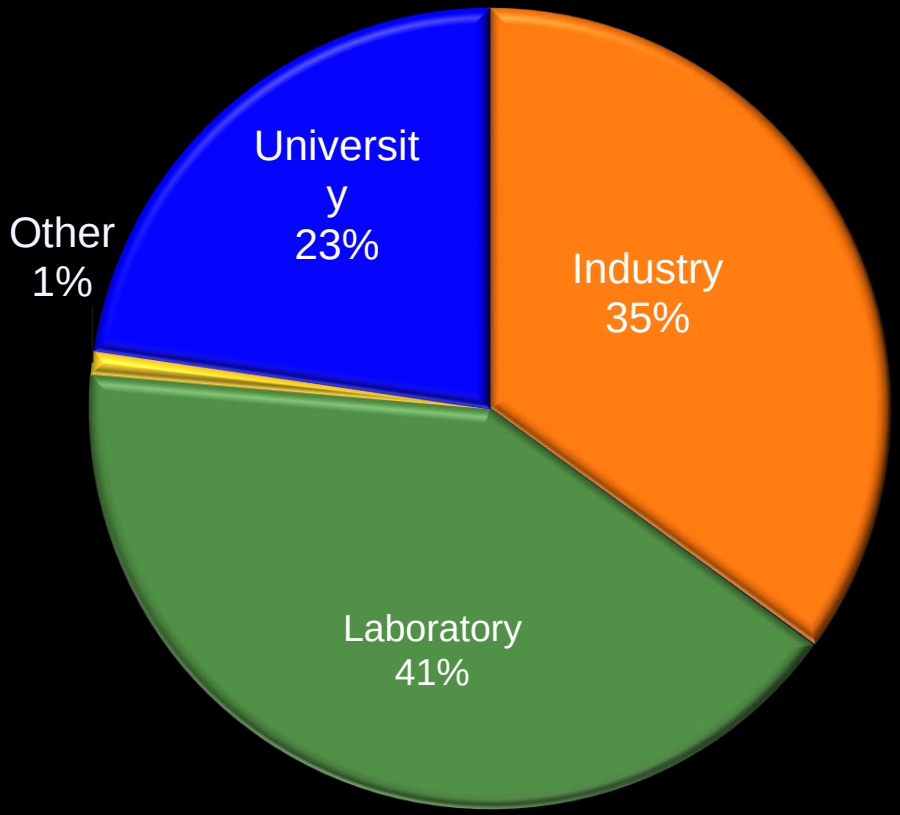
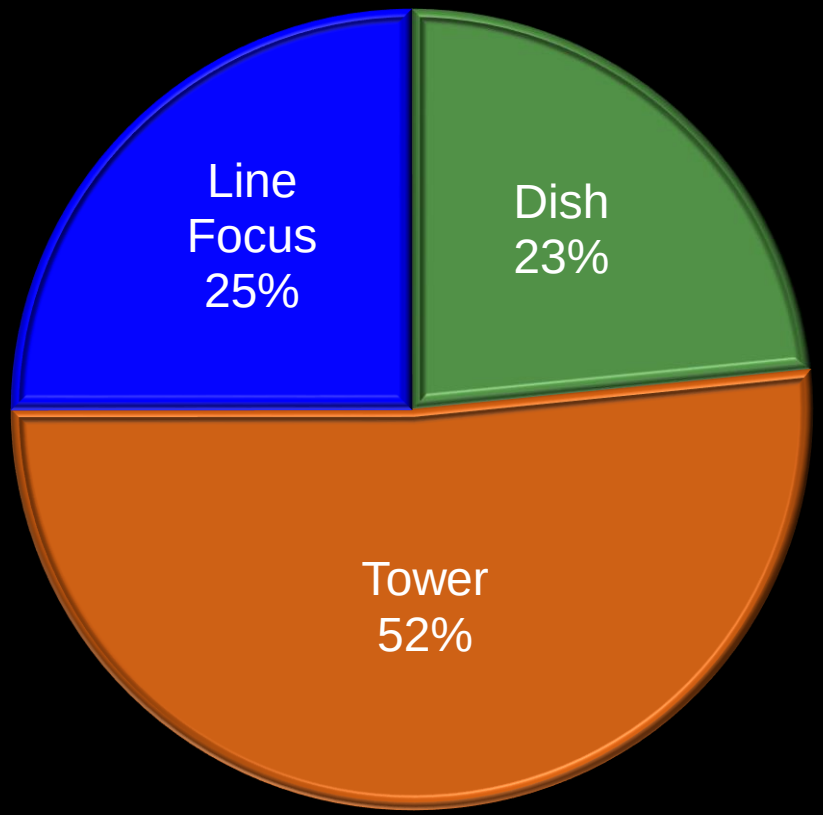

SYSTEMS
COMPONENTS
THERMAL ENERGY STORAGE
$55
$50
$45
$40
$35
$30
$25
$20
$15
$10
$5
0
SMUD
Sandia
NREL
PWR
Abengoa
eSolar
Abengoa
NREL
ORNL
NREL
Boston U.
Penn State
JPL
U. of Arizona
3M
Thermata
BrightSource
HITek
SkyFuel
Sun Trough
PPG
Abengoa
PPG
3M
Alcoa
Skyfuel
Solar Millennium
Abengoa
LANL
SRNL
Sandia
NREL
NREL
Norvich
UCSD
NREL
Oregon Srate
SDSU
ANL
Sandia
Brayton Energy
PWR
GE
MIT
SLAC
SWRI
PNNL
SWRI
NREL
Wilson
Infinia
Brayton
Arizona
UCLA
LANL
ORNL
ANL
SRNL
Acciona
CCNY
Texas A&M
Halotechnics
U. of Alabama
Abengoa
Abengoa
Sandia
Argonne
Terrafore
U. of South Florida
Infinia
NREL
Abengoa
Lehigh
U Conn
Terrafore
Infinia
Acciona
SRNL
General Atomics
PNNL
General Atomics
SENER
U. of Arkansas
US Solar
ELEMENTS
CSP-HIBRED
PREDICTS
SolarMat
National Lab (2013)
MURI (2012)
SunShot R&D (2011)
Baseload (2010)
ARRA Lab Call (2009)
Thermal Storage (2008)
CSP R&D (2007)
Systems
Collectors
Receivers
Power Block
Sensible Heat
Phase Change Materials
Thermochemical
Solid State

FY13 CSP Funding Distribution





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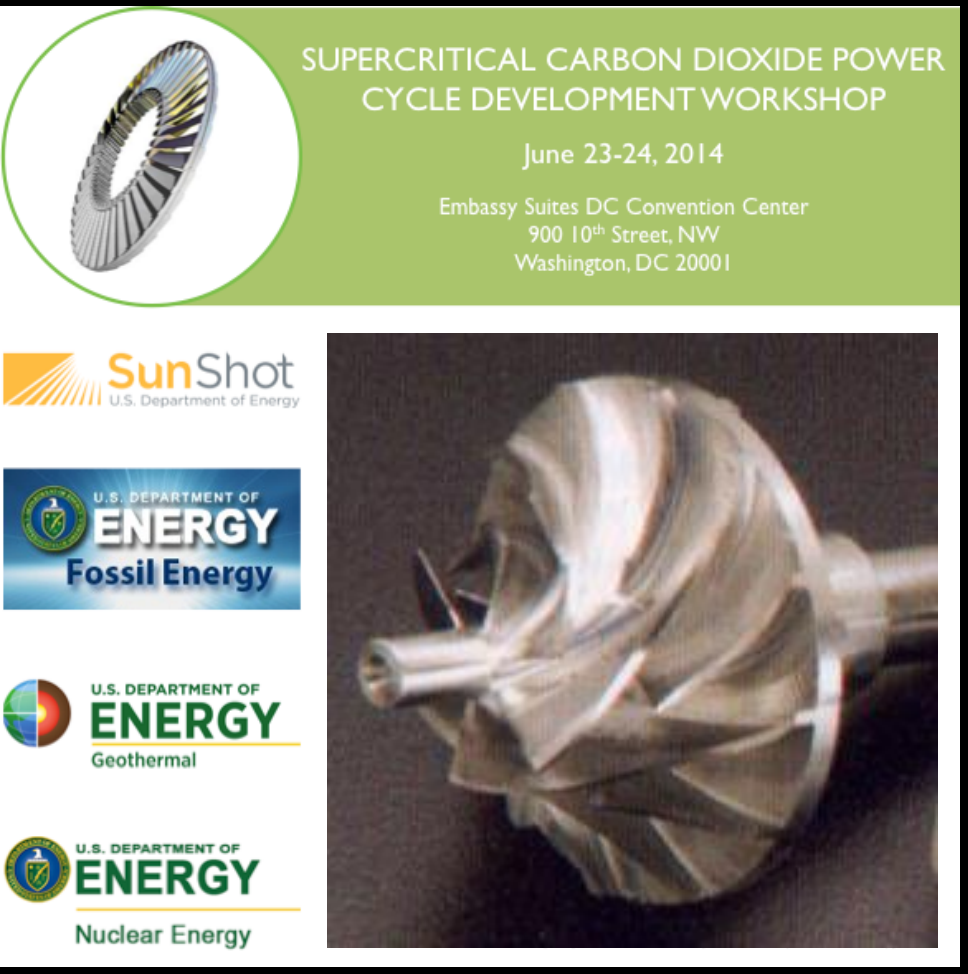
SunShot CSP Partnerships



Mark Lausten, Mark.Lausten@ee.doe.gov
Jesse Gary, Jesse.Gary@ee.doe.gov

arpa·e
CHANGING WHAT'S POSSIBLE

FOCUS

Dr. Howard Branz; Howard.Branz@hq.doe.gov

- 13 Projects ; ~ $30 million in funding
- Hybrid Solar Converters
  - Efficient use of all wavelengths in the solar spectrum
  - Produce electricity and inexpensively-stored heat

HEATS

Dr. Ravi Prasher; Dr. James Klausner

OPEN FOAs

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2014 - The Resurgence of Big Solar!





Project	Solana	Ivanpah	Genesis	Crescent Dunes	Mojave
Utility	APS	SCE + PG&E	PG&E	NVE	PG&E
State	Arizona	California	California	Nevada	California
Size	280 MW	392 MW	250 MW	110 MW	280 MW
Technology	Trough/Storage	Tower	Trough	Tower/Storage	Trough
COD	Oct 2013	Feb 2014	2014	2014	2014
DOE Loan	$1.45 B	$1.63 B	$0.85 B	$.74 B	$1.2 B
Company	Abengoa	BrightSource	NextEra	SolarReserve	Abengoa

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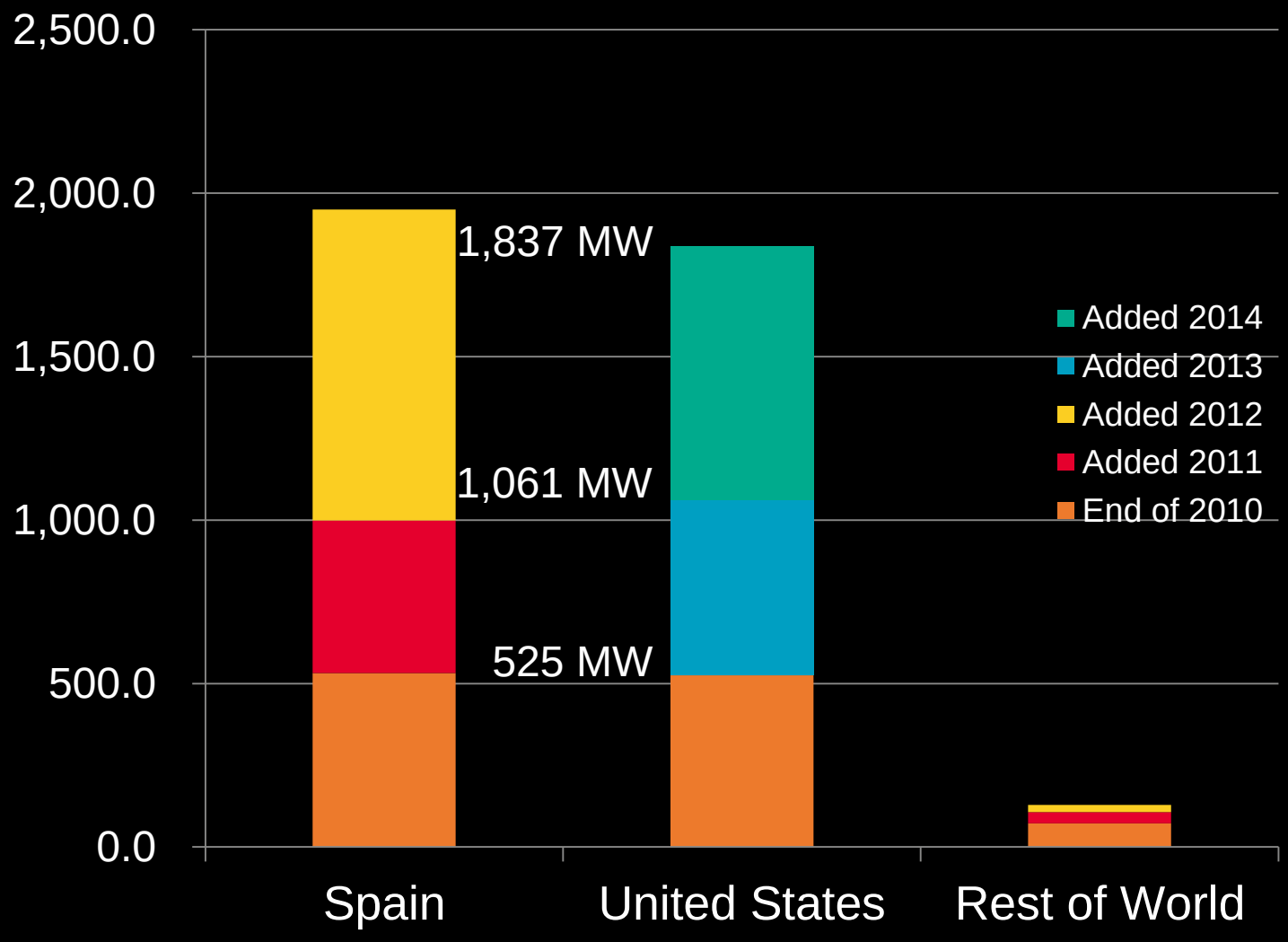
Global CSP Installations



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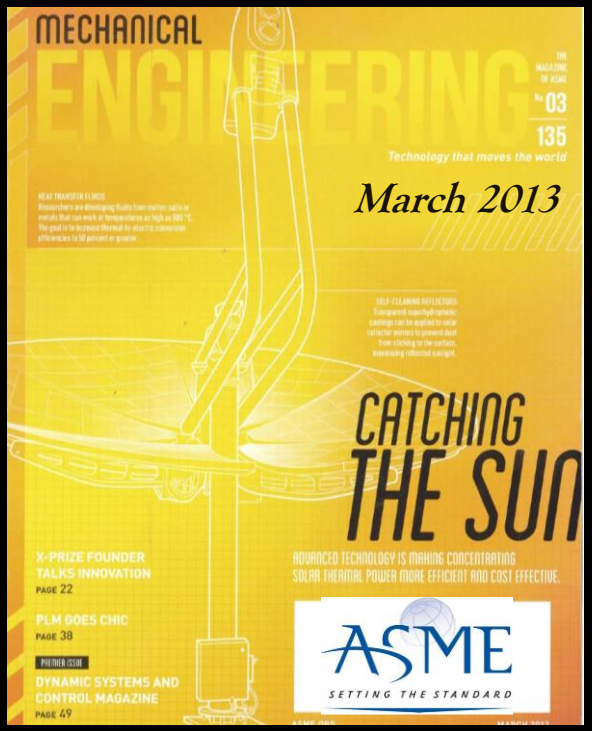
SunShot CSP in the News



The New York Times

New Solar Process Gets More Out of Natural Gas

April 10, 2013

CSP World

Fulfilling the Promise of Concentrating Solar Power

May 2013

Solar Industry

October 3, 2013

The DOE Contemplates The Dawn Of Global CSP

Solar Power World

Technology • Development • Installation

Concentrated Solar Power Gets A Huge Boost

October 10, 2013

ASME ENERGY FORUM

SOLAR PODCAST

PODCAST: CONCENTRATING SOLAR POWER - PART 1

PODCAST: CONCENTRATING SOLAR POWER - PART 2

PODCAST: CONCENTRATING SOLAR POWER - PART 3

SOLAR VIDEO

VIDEO: R&D ENGINEERS AND CONCENTRATING SOLAR POWER

Iom3 The Institute of Materials, Minerals and Mining

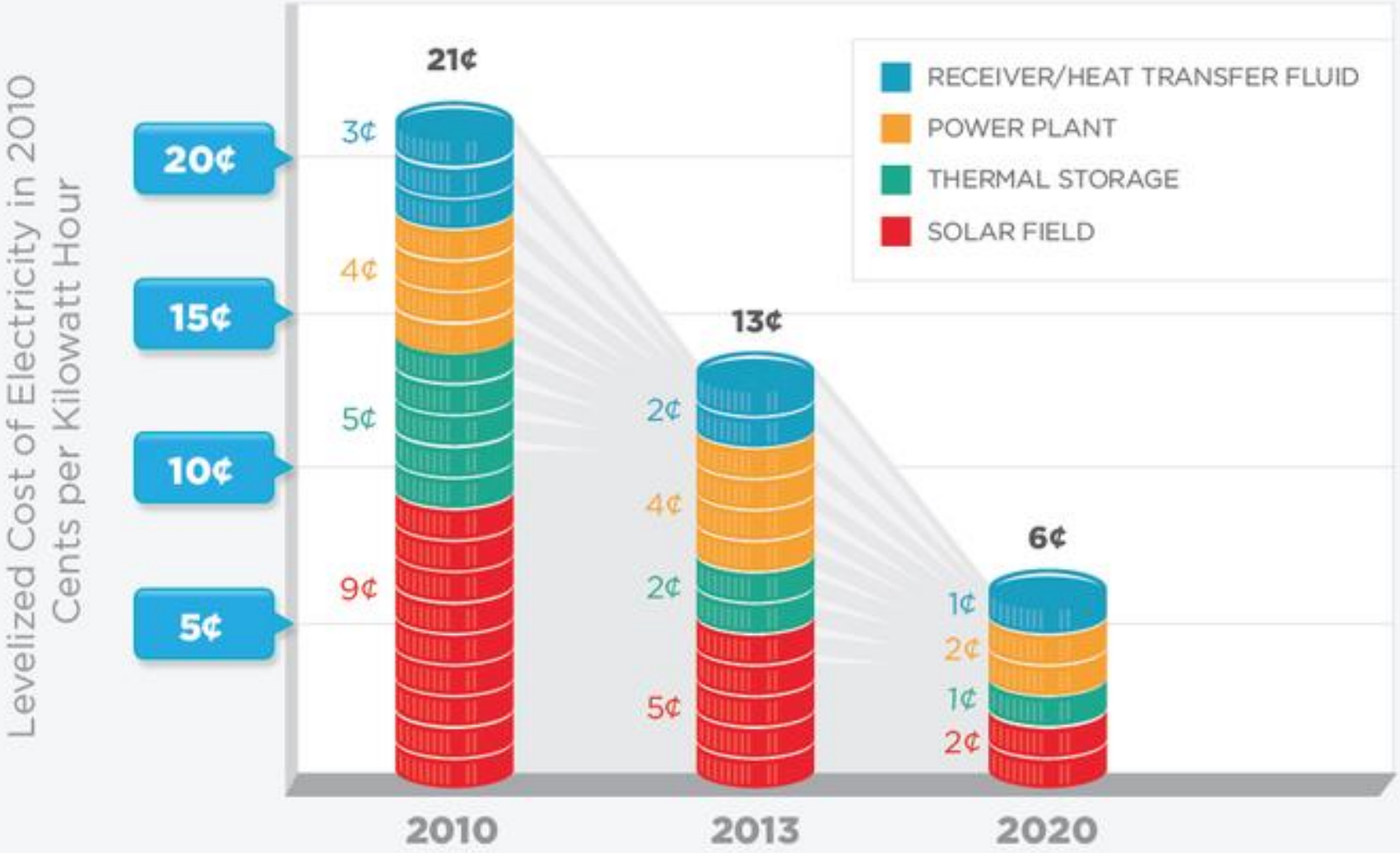
MW MATERIALS WORLD

Feb 1, 2014

Self-cleaning solar panels – ditching the dirt

55% Progress towards 2020 SunShot goals

The Falling Cost of Concentrating Solar Power



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CSP Events at the Summit

SunShot CSP Portfolio Overview

Tuesday (Today) • 1:30 – 3:30 pm • Pacific A

The Future of CSP: Opportunities and Challenges

Wednesday • 1:15 – 3:30 pm • Pacific A

– Moderated discussion with panelists:

- David Hochschild, Commissioner, CEC
- John Candelaria, Policy Director, PUC of Nevada
- Marc Romito, Manager Renewable Energy Programs, Arizona Public Service
- Hank Price, CTO, Abengoa Solar
- Joe Desmond, Senior VP, BrightSource Energy
- Kevin Smith, CEO, SolarReserve
- Buck Martinez, Senior Director Project Development, Florida Power & Light
- Rick Huibregtse, Senior VP of Engineering, eSolar

Technology Forum: Tuesday, Wednesday • 4:00–7:00 pm • California C/D

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Ranga Pitchumani
ranga.pitchumani@doe.gov

Levi Irwin • Mark Lausten • Andru Prescod • Joseph Stekli • Jesse Gary***
Candace Pfefferkorn • Edward Hoegg • Abraham Shultz
Christine Bing • Thomas Rueckert • Vanina Alanes • Stephanie Abraham
Allison Pezzullo • David Mayorga • Jamie Nolan

www.solar.energy.gov/sunshot/csp.html

*Now with ARPA-e **Now with DOE-FEMP

Systems Integration Program

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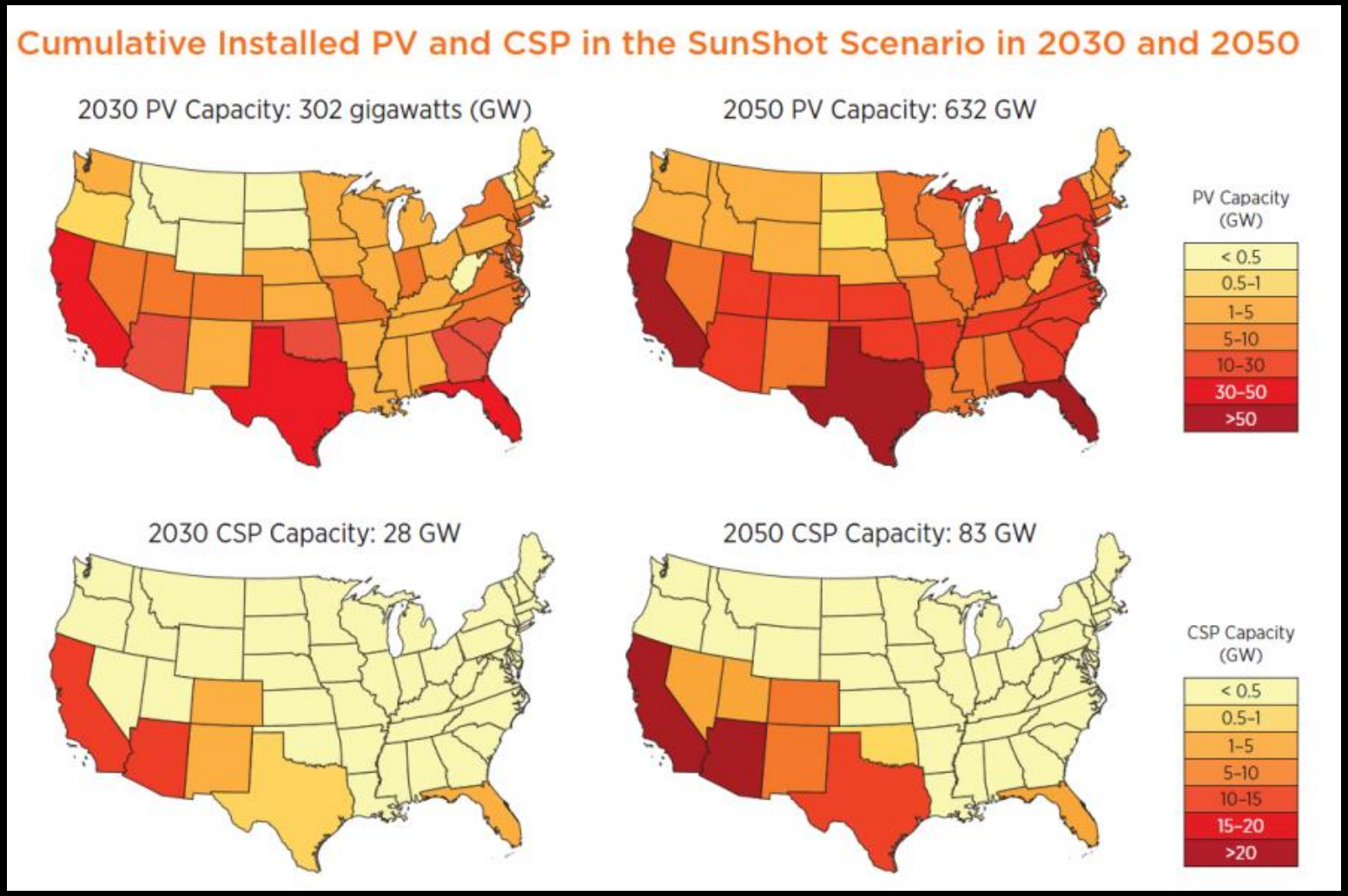
DOE SunShot Vision Study (2012)



Solar can meet **14%** (300GW) by 2030 and **27%** (600 GW) by 2050 of U.S. electricity demand

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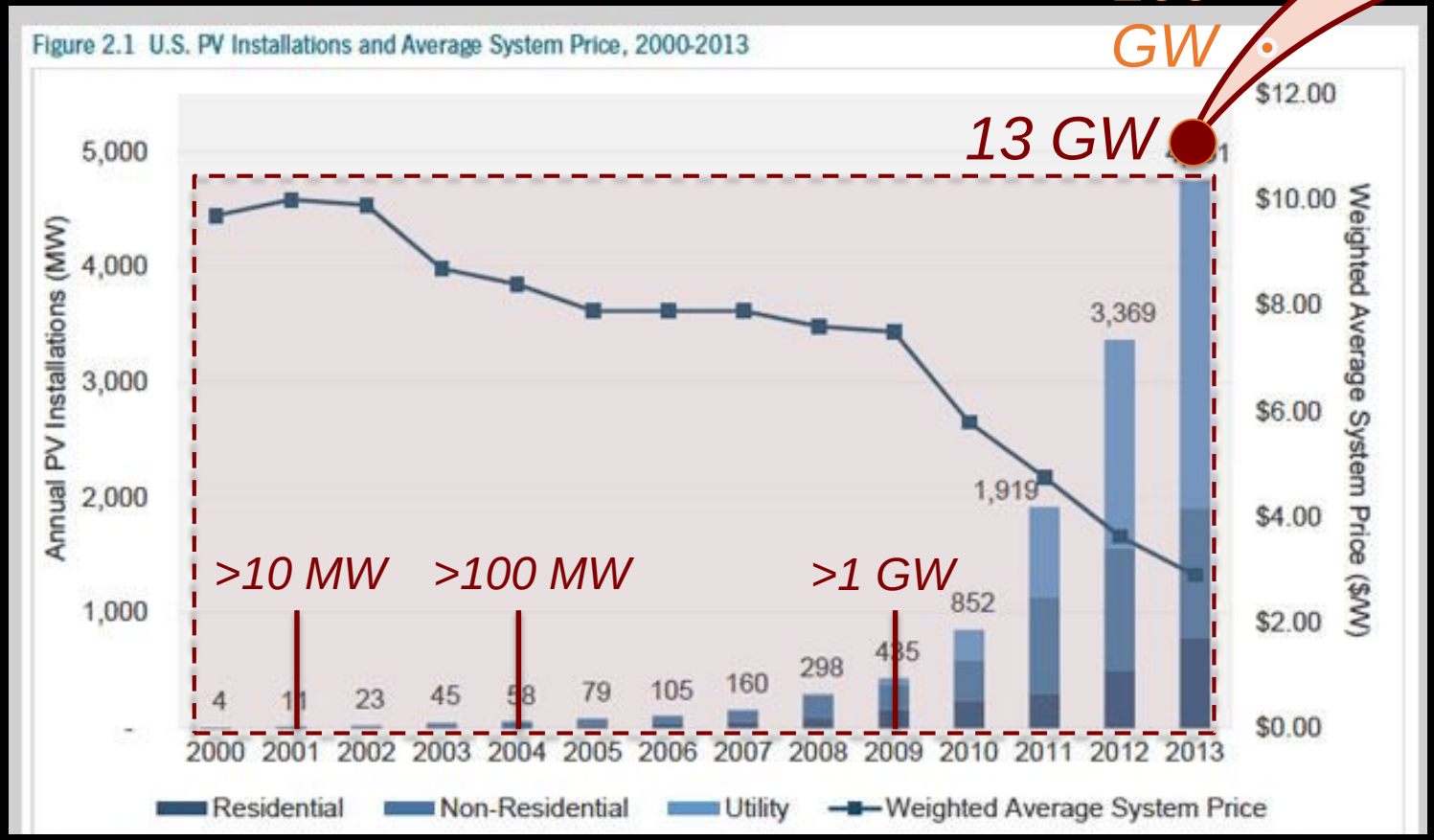
U.S. Solar Growth



100 GW

300 GW

600 GW

13 GW

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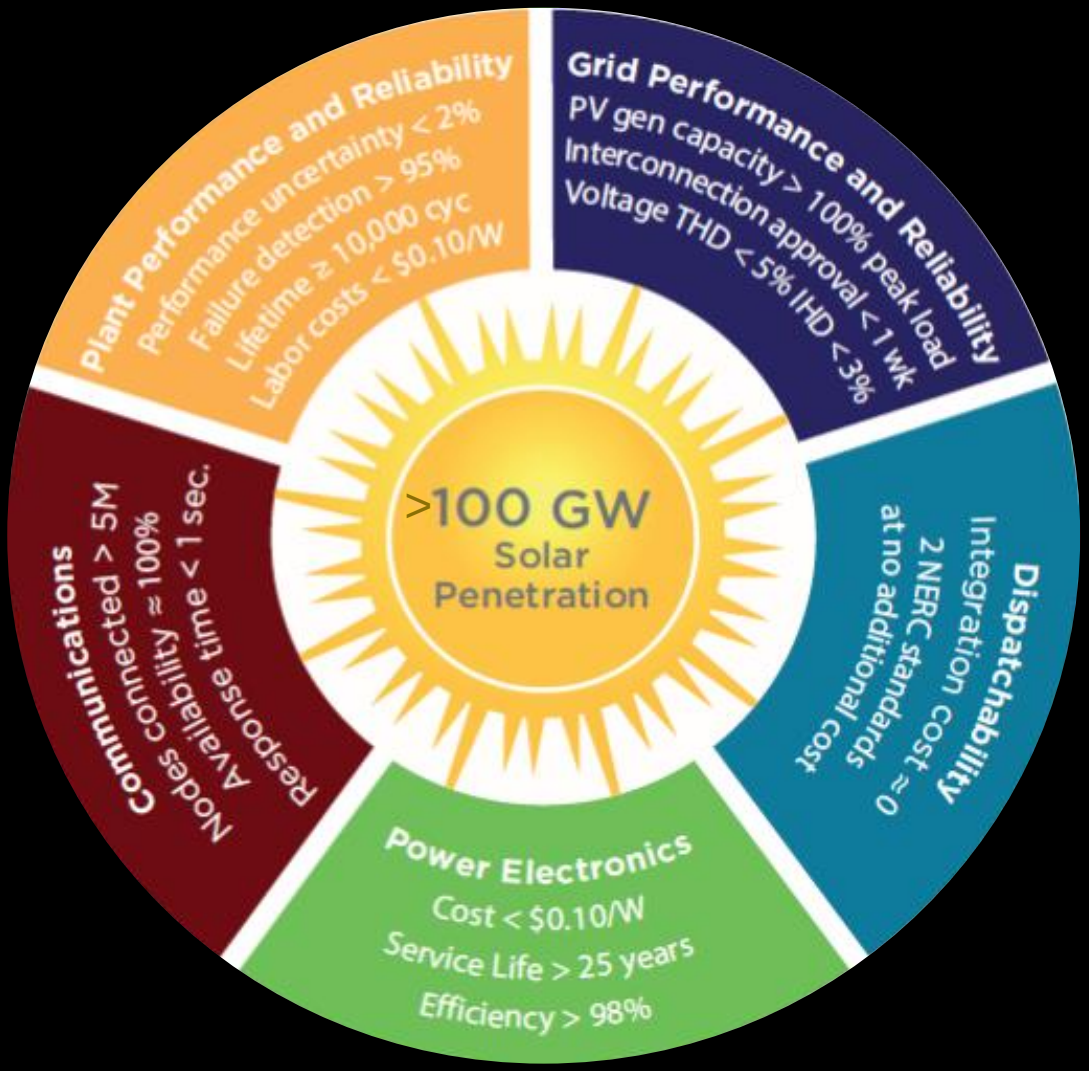
Technical Challenges



Competitive Initiatives

- $4M SUNRISE (2013)
- $1M PREDICTS (2013)
- $77M National Lab R&D (2012)
- $38M HiPen (2012)
- $25M Plug and Play (2012)
- $11M Solar Forecasting (2012)
- $56M BOS-X (2011)
- $30M SEGIS-AC (2011)

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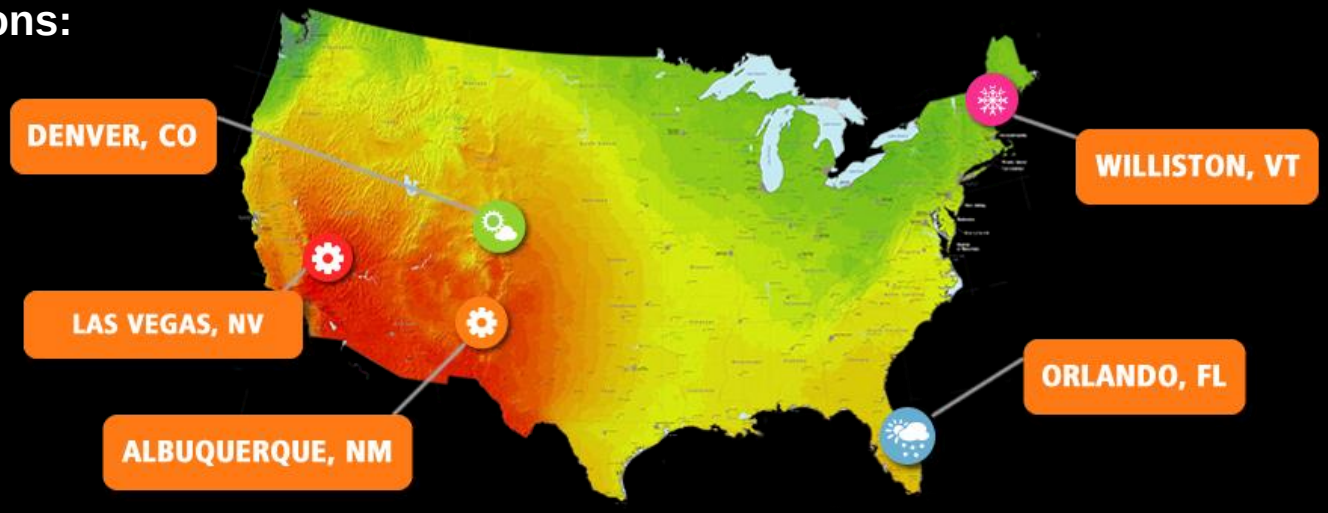
PV Regional Test Centers

Regional Test Centers
Differentiating PV Quality

- **Background / Vision:**
  - Accelerate adoption of renewable energy generation sources by helping U.S. PV manufacturers overcome the commercialization “Valley of Death”
  - Provide technical basis for bankability of PV systems
    - Installation size:
      - Module-level testing: 10-50kW per site
      - System-level testing: 50–300 kW per site
    - Test in multiple climates, using a comprehensive validation approach to compare performance and initial reliability against prediction

- **Locations:**



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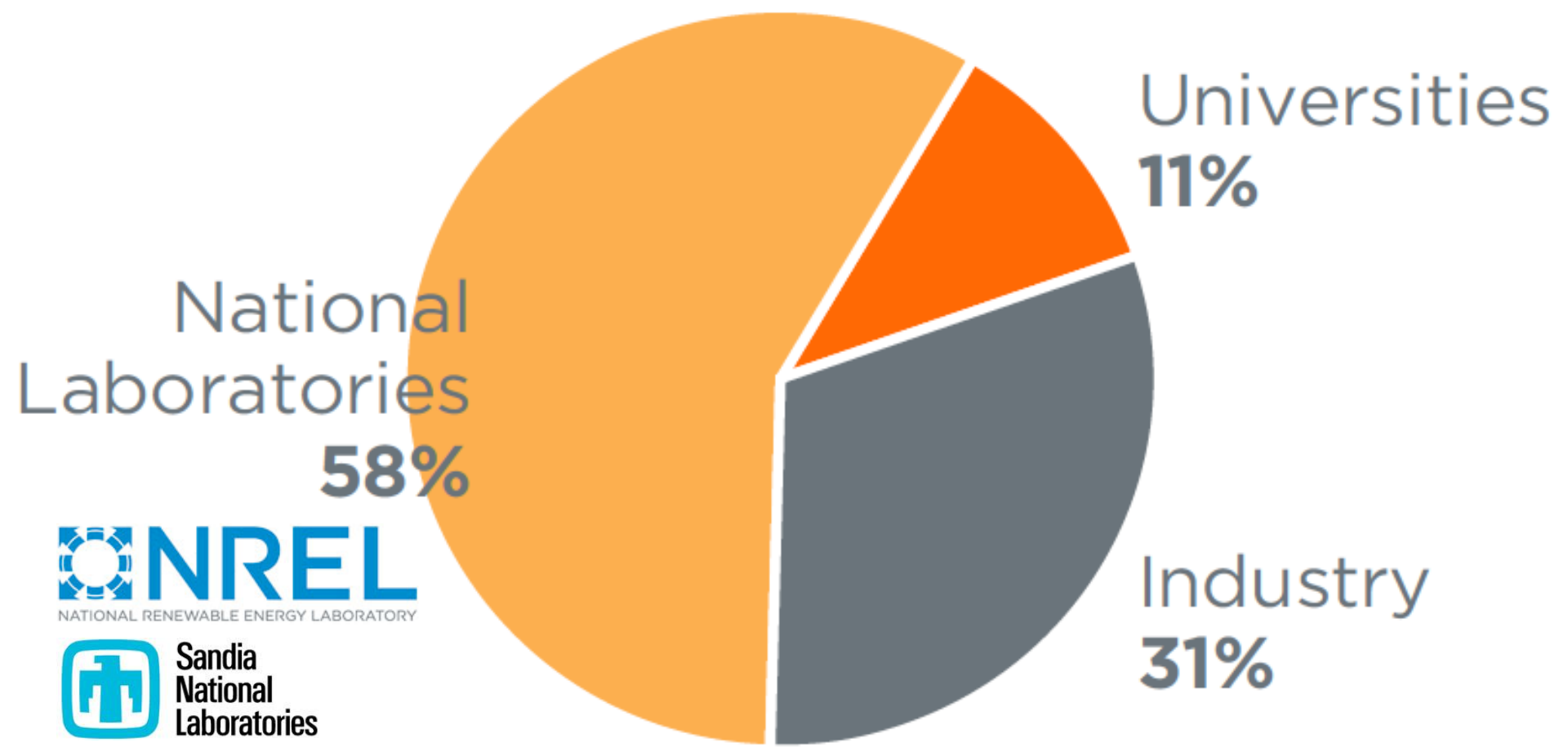
SI Funding Distribution



SunShot SI Recent Highlights

SEGIS-AC awardees and partners are active contributors to the IEEE 1547 working groups, catalyzing the major revision of IEEE 1547 standards making smart PV inverters to be deployable in the U.S. for the first time.

FERC
FEDERAL ENERGY REGULATORY COMMISSION

- SunShot funded research at the National Labs was the basis of the recent FERC ruling to modify the Small Generator Interconnection Procedure (SGIP) that governs the interconnection of wholesale generators
- Lowers the cost of interconnection through a “Fast Track” process, particularly at the high penetration levels.

Forbes

Peter Kelly-Detwiler, Contributor
I cover the forces and innovations that shape our energy future.

ENERGY | 8/07/2013 @ 8:57AM | 4,793 views

Plug-And-Play Residential Solar In Five Years? Fraunhofer USA And Partners Are Working To Make This A Reality

SI Events at the Summit

SunShot SI Portfolio Overview: Tuesday • 1:30 – 3:30 pm • Huntington A/B/C

Solar as a Base Load Power Source
Wednesday • 10:45 – 11:45 am • Huntington A/B/C

- Moderated discussion with panelists: *Mark Rothleder, VP, California ISO • Tony Tewelis, Director, Technology Innovation, Arizona Public Service • Hank Price, CTO, Abengoa Solar • Guy Slicker, Director of Clean Energy Technology, NY Power Authority*

Solar in the Connected Building
Wednesday • 1:15 – 2:15 pm • Huntington A/B/C

- Moderated discussion with panelists: *Byron Washom (UCSD) • Mohammad Shahidehpour (IIT) • Honorable Jeanne Fox (Commissioner, NJ Board of Public Utilities) • David Parsons (Hawaii PUC)*

SunShot Systems Integration Vision Workshop
Thursday • 10:30 am – 2:30 pm • Pacific A

Technology Forum: Tuesday, Wednesday • 4:00–7:00 pm • California C/D

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David Mayorga • Jamie Nolan

www.solar.energy.gov/sunshot/systems_integration.html