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U.S. Department of Energy

Reliability and the SunShot Initiative

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Solar Energy Technologies Office

Outline

- **The SunShot Initiative and the Solar Energy Technologies Office**
- Reliability Projects
- Current Opportunities

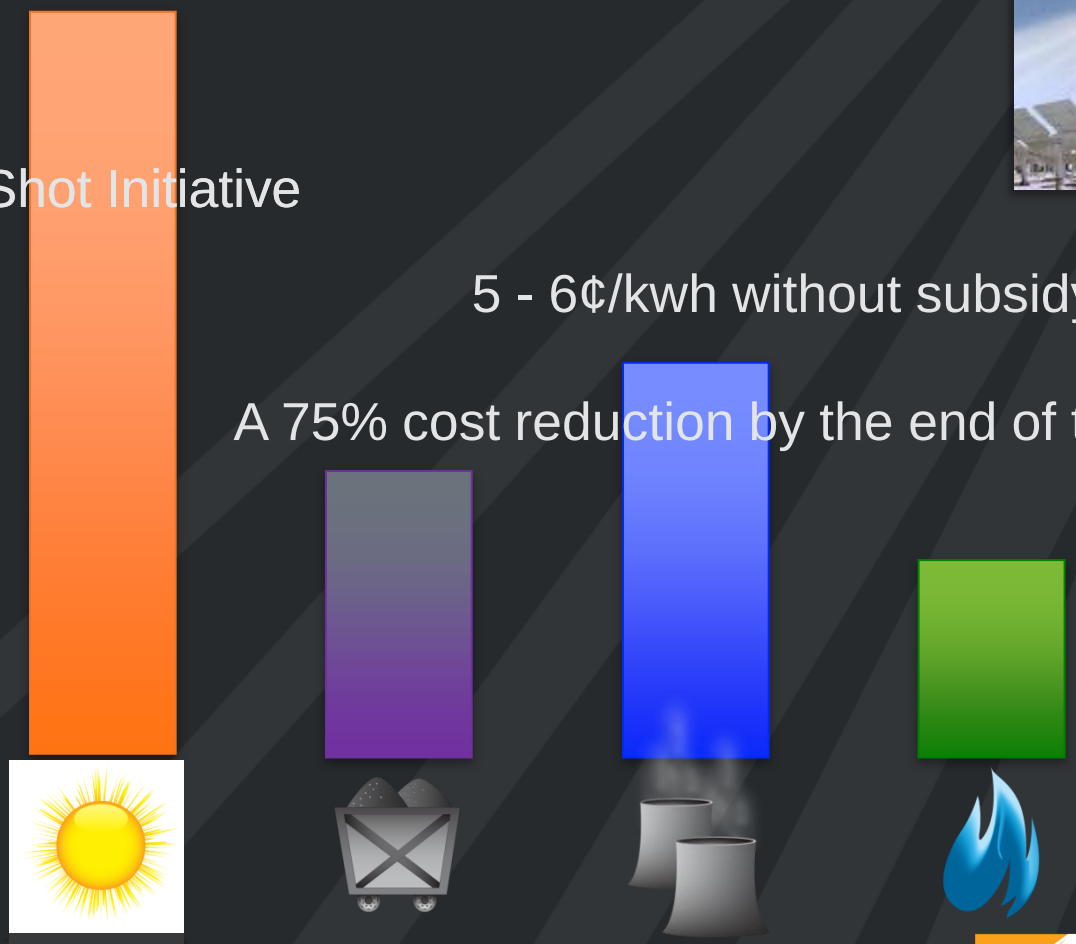
SunShot Initiative

Price

SunShot Initiative

5 - 6¢/kwh without subsidy

A 75% cost reduction by the end of the decade



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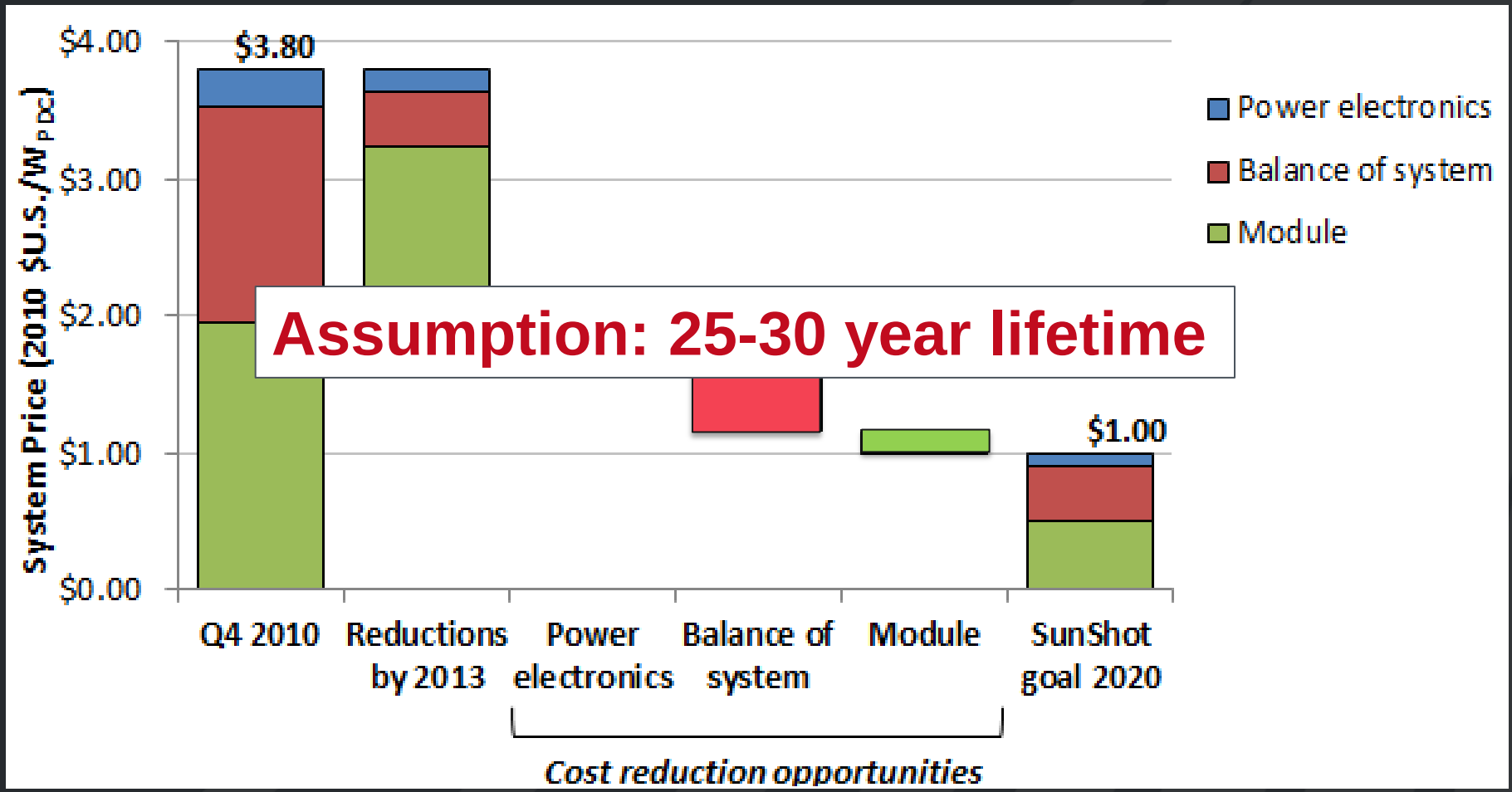
SunShot Utility Scale Progress Q4 2013



Sources: Margolis , R., et al. (2012). "*SunShot Vision Study*." DOE/GO-102012-3037. Golden, CO: National Renewable Energy Laboratory, pp. 265. Accessed 2013: http://www1.eere.energy.gov/solar/pdfs/47927_appendices.pdf; Goodrich, A; James, T; and Woodhouse, M. "*Residential, Commercial, and Utility-Scale Photovoltaic System Prices in the United States: Current Drivers and Cost Reduction Opportunities.*" NREL Technical Report No. TP-6A20-53347, Available Online at: www.nrel.gov/docs/fy12osti/53347.pdf . ; NREL internal (PV system cost) analysis (September 2013).

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Solar Energy Technologies Office Portfolio

- **Photovoltaics R&D** - Advances R&D that has resulted in US leadership in world records, scientific publications, and patents to provide US industry technology advantages
- **Concentrating Solar Power R&D** - Develops concentrating solar thermal technologies with thermal energy storage to meet SunShot goals
- **Systems/Grid Integration** - Develops technologies to enable integration of solar power with the grid for reliability and resiliency
- **Soft Costs**- Work with state and local governments to reduce red tape which can be ~50% of residential costs
- **Tech to Market** - Increase US market share for manufacturing value add commensurate with domestic market demand through manufacturing process R&D

- **SETO FY14 Budget: $257 million**

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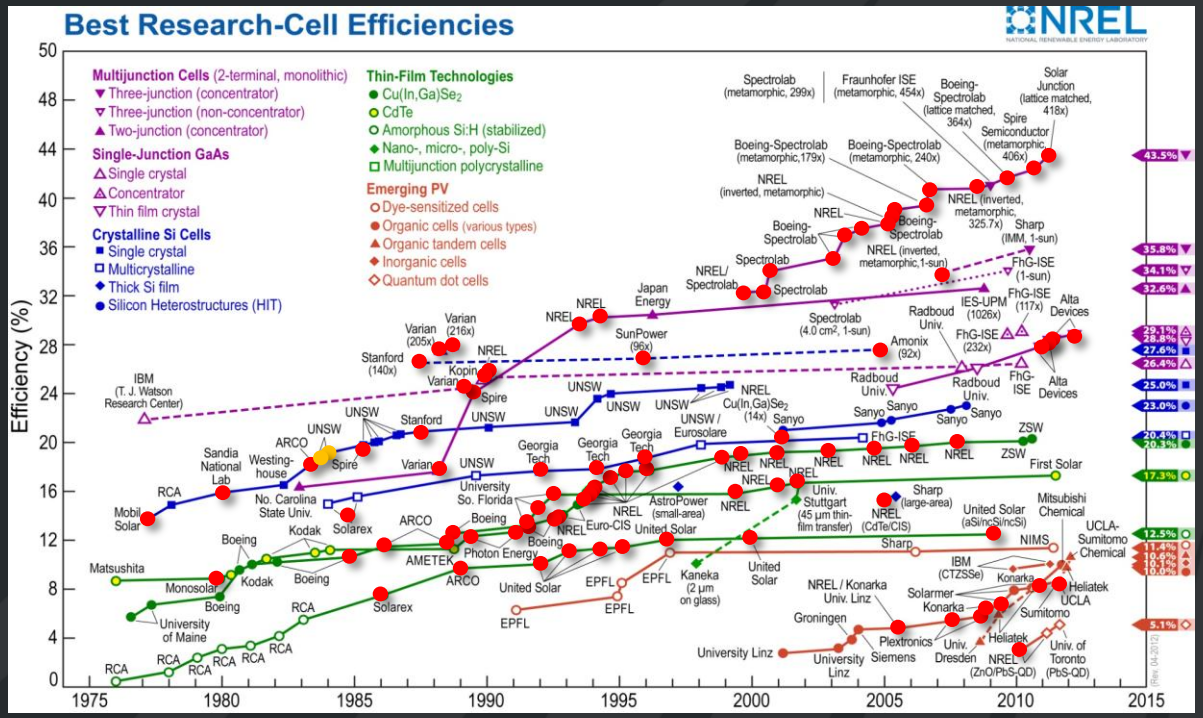
Photovoltaics R&D

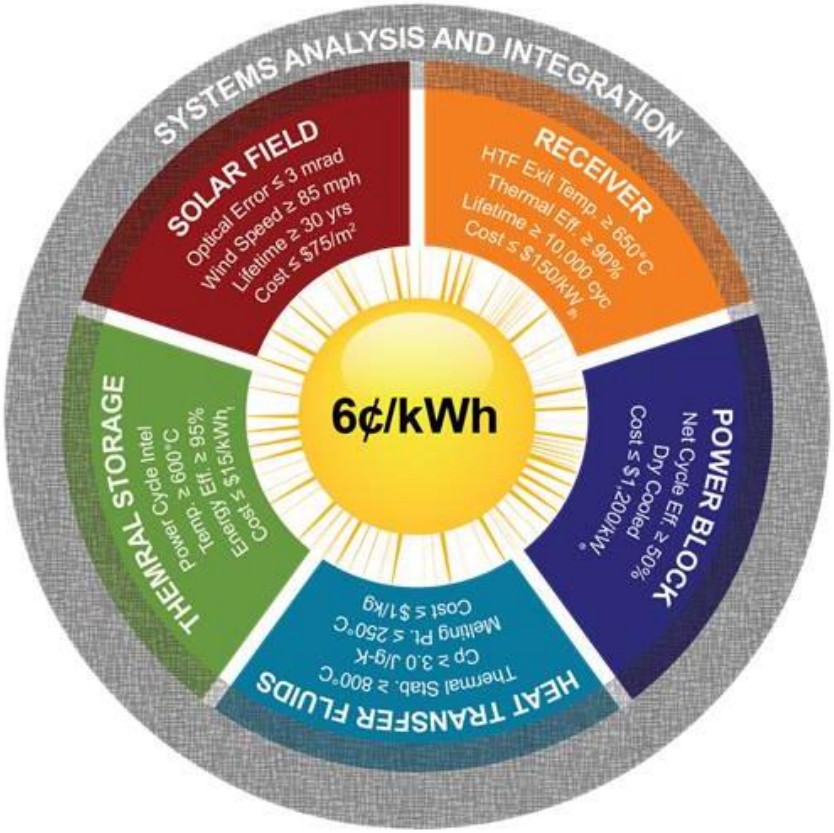
- New materials and device concepts to increase solar cell efficiency and decrease cost



- Addressing the R&D needs of the PV industry
  - **Improving reliability**
  - Training a diverse, technical workforce to support innovation
  - Bridging the gap between basic science and applied PV research

Concentrating Solar Power R&D

Deconstructing 6¢/kWh



Competitive Programs

- CSP: ELEMENTS (2014)
- CSP-HIBRED (2013)
- PREDICTS (2013)
- SolarMat (2013)
- SunShot MURI (2012)
- National Lab R&D (2012)
- BRIDGE (2012)
- SunShot CSP R&D (2011)
- Incubator (Recurring)
- CSP Baseload (2010)
- ARRA (2009)
- Thermal Storage (2008)

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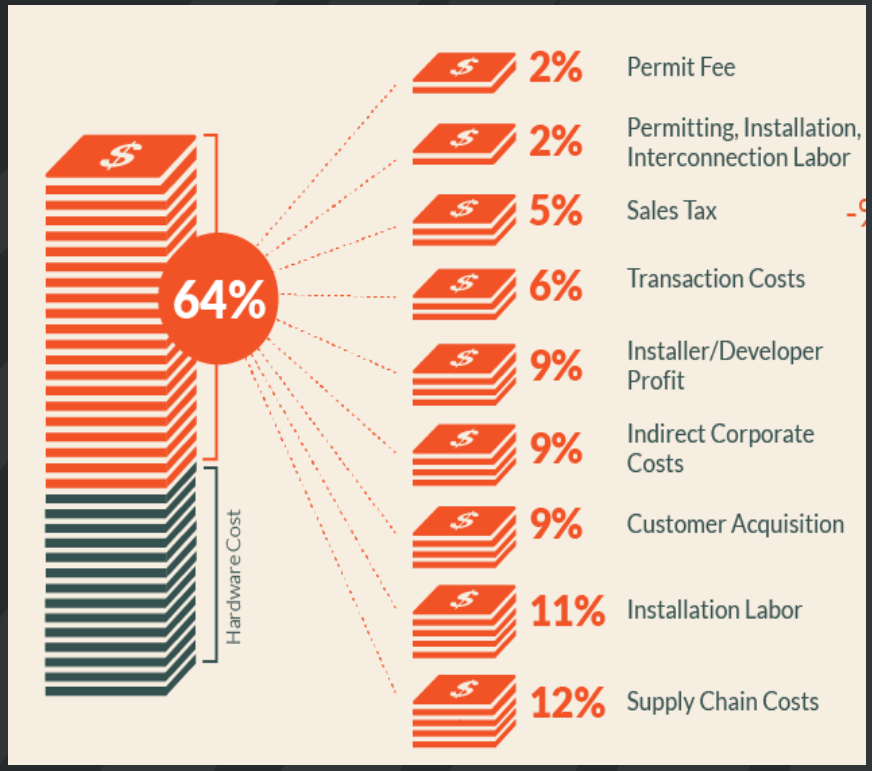
Systems Integration

Goals

- **BOS Costs:** Reducing the costs of power electronics and balance of system hardware
- **Bankability:** Reducing the risk associated with the use of new technologies
- **Grid Integration:** Establishing a timely process for integrating high penetrations of solar technologies into the grid in a safe, reliable, and cost-effective manner while providing value to the system owner and the utility grid.

Soft Costs

- Focus areas:
  - State / local support to reduce red tape
  - Innovative small businesses to help accelerate adoption of solar
  - Enabling a solar workforce
- Performed at state and local government, national laboratories, research universities, and industry



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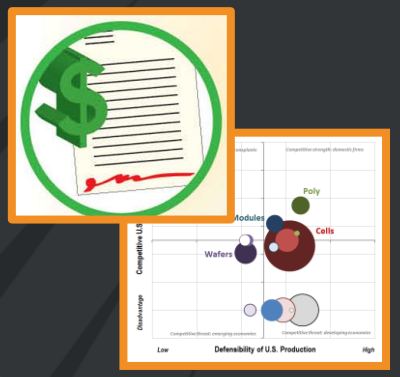
Technology to Market & Strategic Initiatives



Bottom-up cost analysis (PV, CSP, systems-level)
Market analysis

Competitiveness analysis
Uncertainty analysis (finance, policy)

Commercialization
Incubator program, SBIR

QBotix
Solibot R-225
MOSAIC

Strategic planning
SunShot targets

6 ¢/kWh

Innovations in Manufacturing
SolarMat, SUNPATH

Suniva
The Brilliance of Solar Made Sensible
ABENGOA SOLAR

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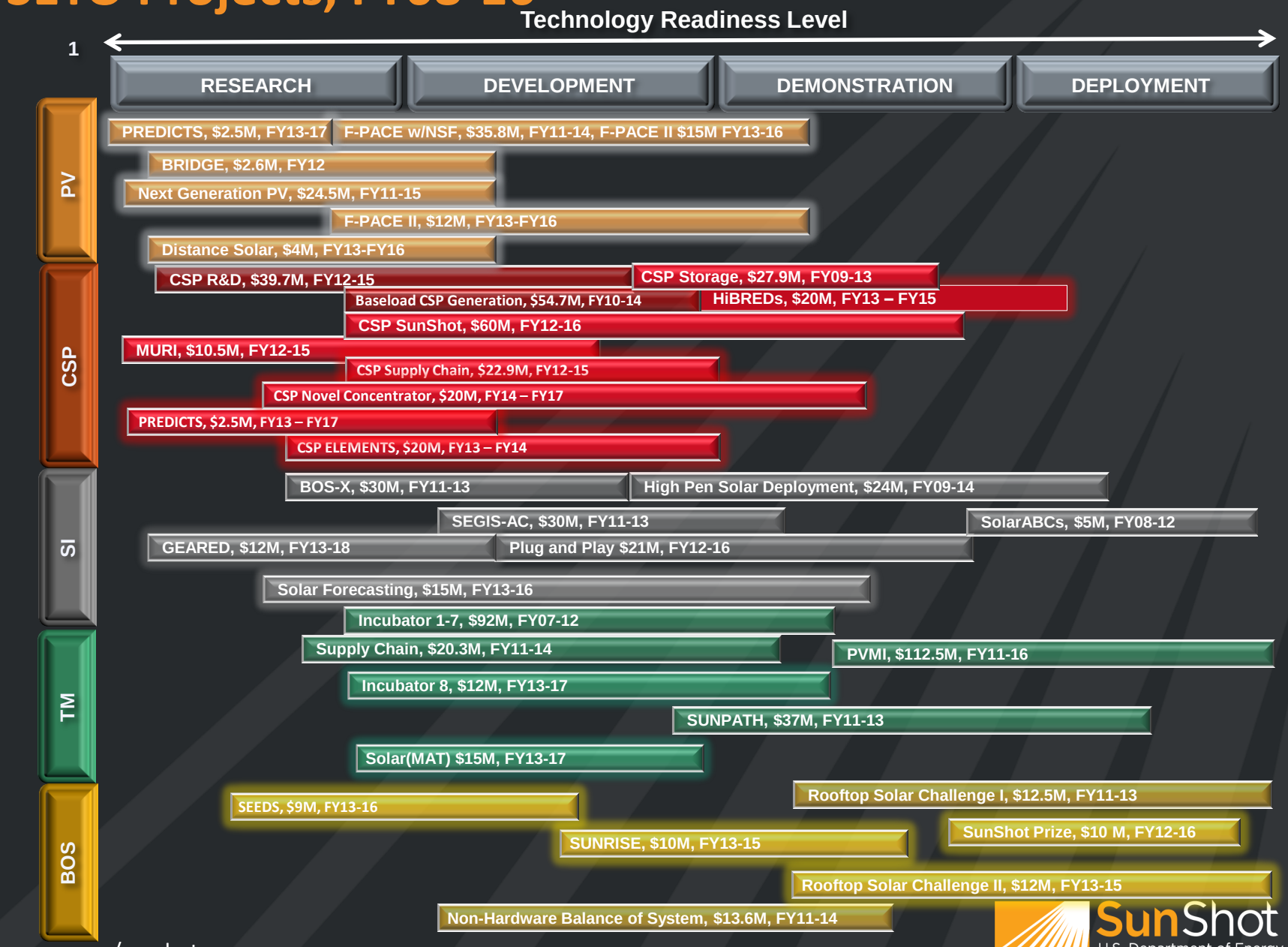
SETO Projects, FY08-16



Outline

- The SunShot Initiative and the Solar Energy Technologies Office
- **Reliability Projects**
- Current Opportunities

Reliability Overview

- National Laboratories (NREL and Sandia)
- PREDICTS Funding Opportunity Announcement (FOA)
- Reliability tasks incorporated into individual projects

Performance and Reliability: Key Activities at the national labs

NREL NATIONAL RENEWABLE ENERGY LABORATORY	Sandia National Laboratories
FY14 Funding: $11M	FY14 Funding: $8M
• QA Task Force • Qualification Plus • Degradation Rate Calculations • Regional Test Center Support	• Performance Modeling Collaborative • Arc Faults • AC Modules • Regional Test Center Support

Regional Test Centers

- **Background / Vision:**
  - Accelerate adoption of solar energy generation sources by helping U.S. PV manufacturers overcome the challenges on the path to commercialization
  - 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:**

Physics of Reliability: Evaluating Design Insights for Component Technologies in Solar (PREDICTS)

Topic 1: Development of physics- and chemistry-based models to:

- Quickly and accurately predict degradation modes
- Map active pathways associated with macroscopic failure
- Develop relationship networks for relevant physical and chemical processes
- Determine component lifetimes

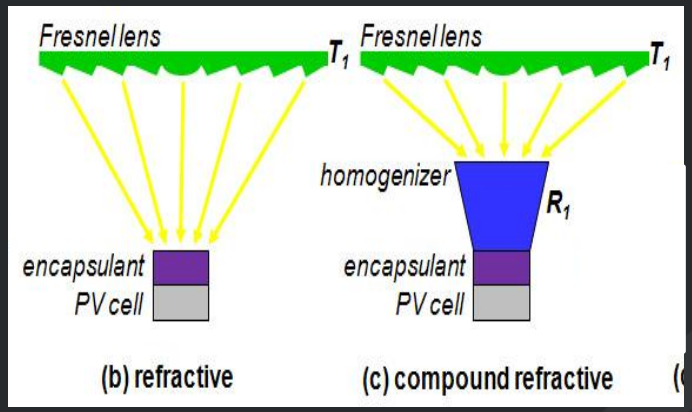
Topic 2:

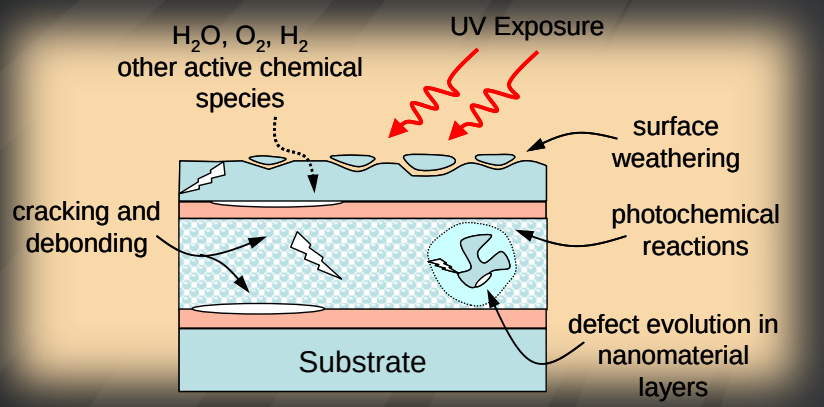
- Collaborative development and initial implementation of industry standard tests for microinverter and microconverter reliability in stand-alone and module-integrated configurations
- Extensive laboratory and field testing to validate tests and test protocols to ensure broad applicability across the industry
- Testing to be vendor- and technology-neutral

Max. award duration
3 years
Max award size
$2.25M
Total cost (DOE + Cost-share)
$9.5M
Total DOE funding
$7.5M
Cost-share minimum
20%

Coupled Thermo-Mechanical and Photo-Chemical Degradation Mechanisms that determine the Reliability and Operational Lifetimes for CPV Technologies

Reinhold H. Dauskardt, Stanford University with BAPVC, Spectrolab and NREL





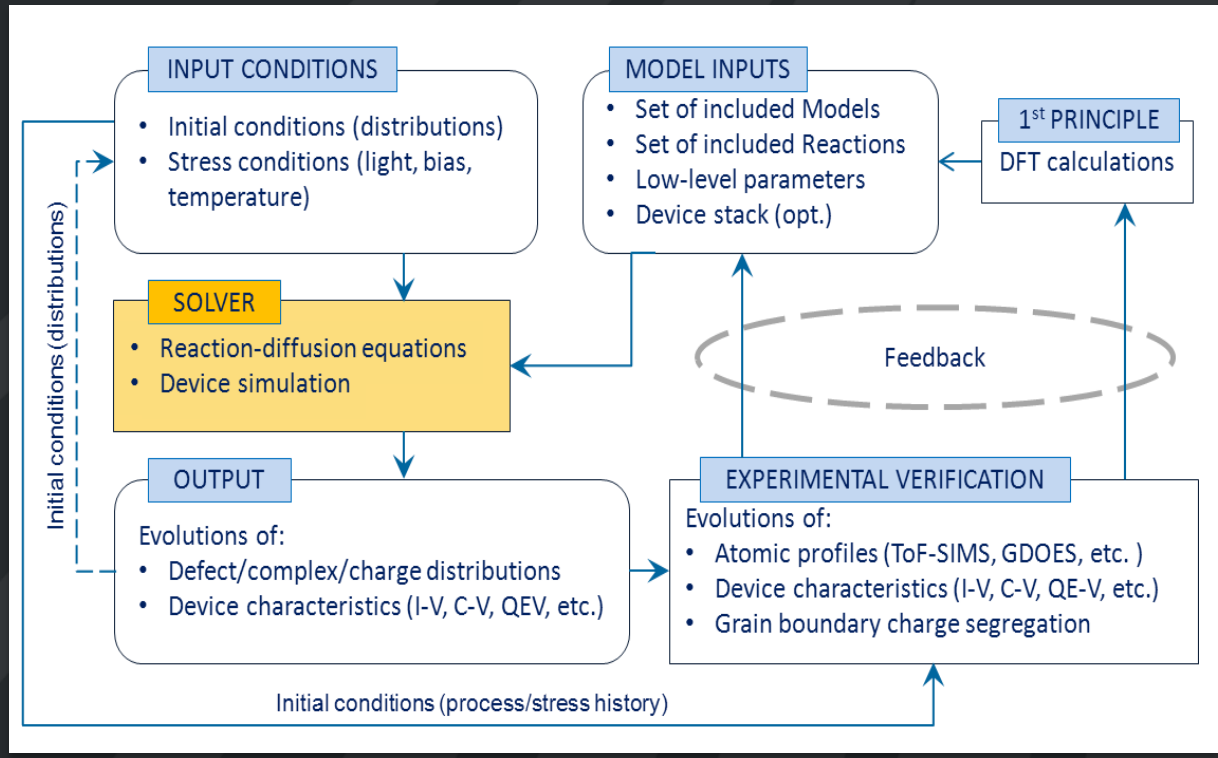
CPV systems are an ideal PV vehicle with elevated “stress” parameters for reliability studies

Focus: I**dentify** and **characterize** the *coupled* intrinsic thermo-mechanical and photo-chemical degradation mechanisms that determine the reliability and operational lifetimes for CPV technologies with *direct implications* for other PV technologies.

Unified Numerical Solver for Device Metastabilities in CdTe Thin-Film PV

Dragica Vasileska, Arizona State University with First Solar, NREL and CSU

- Integrating 1st principle DFT, kinetics of materials, semiconductor physics and characterization into a unified 2D solver for understanding the performance and metastabilities of CdTe



PREDICTS: CSP and Power Electronics

Physics-Based Reliability Models for Supercritical-CO_2 Turbomachinery Components: Azam Thatte, GE Global Research with Southwest Research Institute

Developing predictive performance and reliability models for key components of supercritical CO_2 expanders and heat exchangers used for lower cost CSP

Predictive Physico-Chemical Modeling of Intrinsic Degradation Mechanisms for Advanced Reflector Materials: Ross Larsen / NREL with Abengoa

Developing predictive models for intrinsic degradation and failure mechanisms of advanced materials and coatings targeted for use in CSP systems

Module Level Power Electronics Reliability and Accelerated Testing Standards Development: Jack Flicker/ Sandia National Laboratories with several partners

Analysis of failure in module level power electronics taking into account field reliability data and usage environments; recommendations for standard reliability test protocol

SERI IUS

Solar Energy Research Institute
for India and the United States

DOE Basic Research Needs/Priority Areas

- Maximum energy from solar photons at low costs
- Nanostructures for solar energy conversion; low cost and high efficiencies
- Materials and architectures for solar energy; assembling complex structures

Critical Barriers called out by EERE SunShot Vision Study

- Understand materials and structures to improve conversion efficiency
- Optimize molecular, polymeric and nanocrystalline structures to produce systems
- High-throughput and continuous (roll-to-roll) processes that do not require high temperature or vacuum

Critical Barriers–India

- Earth abundant and green materials
- Low capital manufacturing at multiple scales
- Distributed power generation and integration
- **Degradation mechanisms (reliability, dust)**

Bay Area PV Consortium: Encapsulation and Reliability Thrust

- Reinhold Dauskardt (Stanford): *Reliability and Operational Lifetimes for BAPVC Technologies*
- Roger French (Case Western): *PV Module Performance & Lifetime Prediction: Inserting New Technologies Without Lifetime Penalty*
- Rachel Segalman and Jeffery Urban (Berkeley): *Novel Polymer-Nanocrystal Composite Barrier Layers*
- Bernard Kippelen and Samuel Graham (Georgia Tech): *Tailoring Electrostatic Interactions to Produce Hybrid Barrier Films for Photovoltaics*

Outline

- The SunShot Initiative and the Solar Energy Technologies Office
- Reliability and Performance Projects
- **Current Opportunities**

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May 19-22
Anaheim, CA

SAVE THE DATE

SunShot Grand Challenge Summit 2014

Keynote Speakers and Panel Sessions

- From business leaders, academia, and policymaking communities of the U.S. solar energy industry.

Industry Workshops

- Focused discussions to encourage stakeholder feedback.

Peer Review

- SunShot projects will be evaluated by peer reviewers.

Technology Forum

- Experience our interactive technology demonstrations and poster displays from SunShot awardees, interact with solar industry innovators and foster new partnerships.

Open Funding Opportunity: SolarMat 2

- Purpose:
  - Spur photovoltaic (PV) and concentrating solar power (CSP) manufacturing and supply chain companies in the U.S.
  - Assist in the development and demonstration of innovative manufacturing technologies
  - Help create cost advantage for domestic manufacturers
- Details:
  - Total federal funds available: $25M
  - Minimum industry cost-share: 50%
  - Project period: 1 to 4 years
  - Number of expected awards: 6 to 10
  - Concept Paper must be submitted by March 12 5:00 pm EST

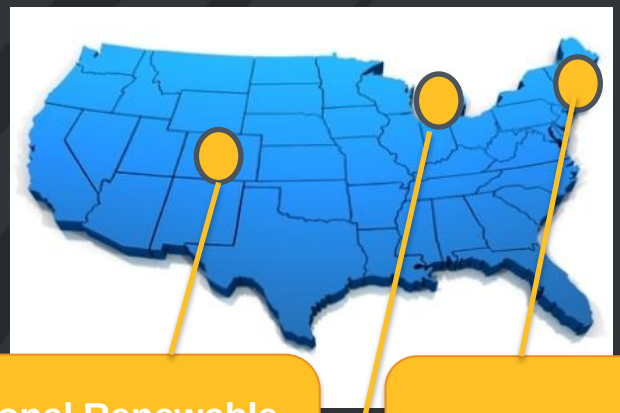
https://eere-exchange.energy.gov
DE-FOA-001018

SunShot Postdoctoral Research Awards

Develop the next generation of solar scientific leaders

- Solar research topic areas include:
  - Fundamental understanding of mechanisms of degradation in PV devices and research developing physics based models for device degradation.
  - Reducing the gap between module and PV cell efficiencies
  - Advanced modeling, visualization and control of photovoltaic systems and grid integration
- U.S. citizen applicant finds research mentor and writes joint proposal
- **20% Innovation Time – A unique fellowship opportunity**
  - Fellows pursue innovative self-directed projects in addition to mentored research project

Current Jobs of Alumni



National Renewable Energy Lab: Staff Scientist

Yale University: Staff Scientist

University of Michigan: Assistant Professor

APPLICATIONS DUE APRIL 30, 2014

http://www1.eere.energy.gov/education/postdoctoral/

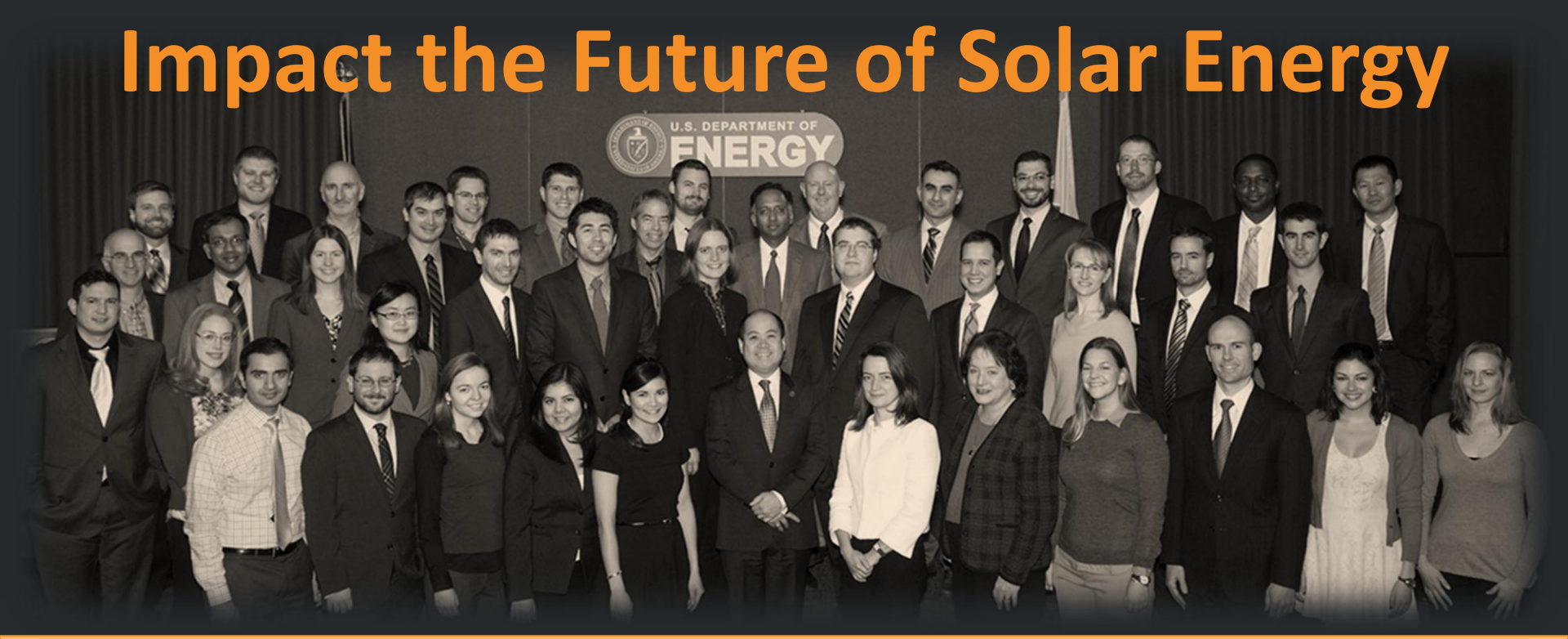
SunShot Science & Technology Policy Fellowships

- Two-year fellowships with DOE in Washington, DC
- Active involvement in current and new R&D programs
- Professional mentorship from DOE leadership
- Open to BS, MS, and PhD graduates
- Competitive stipend, benefits, and travel allowance

Applications due: January 31 | May 30 | September 30

Website: eere.energy.gov/education/stp_fellowships.html

Impact the Future of Solar Energy



Join our team! Take on the SunShot grand challenge to make solar energy cost-competitive with traditional energy sources by 2020.

- Photovoltaics
- Systems Integration
- Tech to Market
- CSP
- Soft Costs

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Thank You!

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