U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE

CSP Performance and Reliability

R&D Virtual Workshop Series
Concentrating Solar Power Program

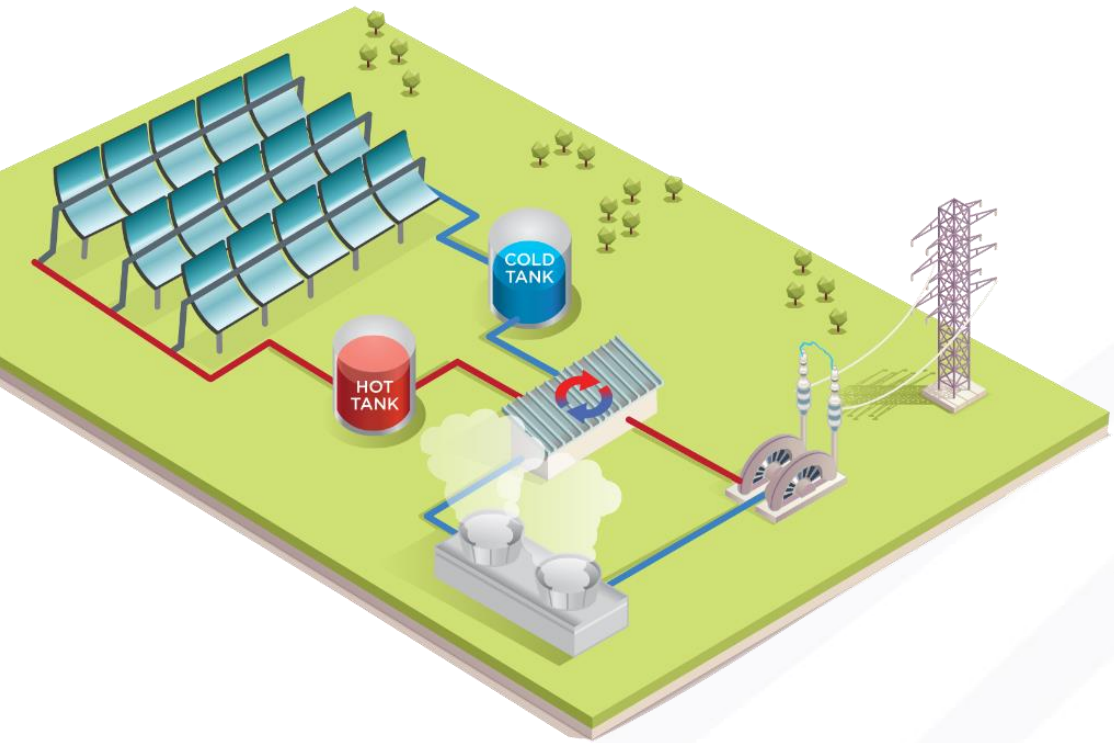
Avi Shultz, CSP Program Manager, US DOE

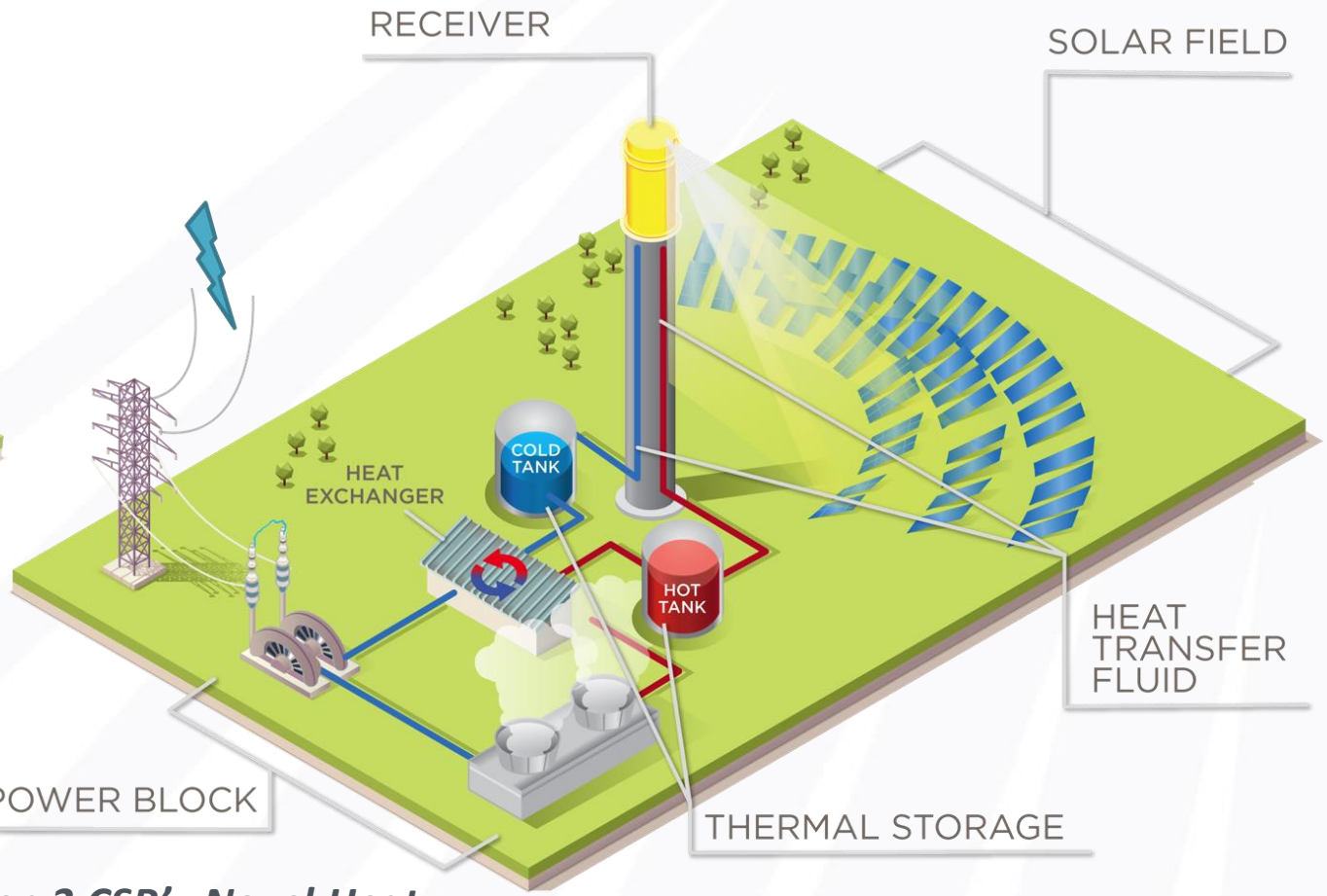
Mark Lausten, CSP Technology Manager, Contractor to US DOE
Shane Powers, CSP Technology Manager, Contractor to US DOE
Rajgopal Vijaykumar, CSP Technology Manager, US DOE

Agenda

Time	Session
11:00AM– 11:10AM	**Introduction and Workshop Overview** Avi Shultz, *DOE Program Manager, Concentrating Solar Power* Mark Lausten, *Technology Manager, Concentrating Solar Power*
11:10AM– 11:35AM	**Panel – CSP Best Practices Study** Mark Mehos, *NREL* Hank Price, *Solar Dynamics* Bob Cable, *Consultant, former Acciona Plant Manager NSO* Greg Kolb, *Consultant, former Distinguished Member of SNL*
11:35AM– 12:15PM	**Innovations for CSP Performance and Reliability** Panel and Audience Question and Answer
12:15 PM	**Closing Remarks**

CSP with Storage is Solar Energy On-Demand





5.2 GW of **Parabolic Trough** operating globally (790 MW under construction)

Oil-Based Troughs with steam rankine cycle (~400 °C)

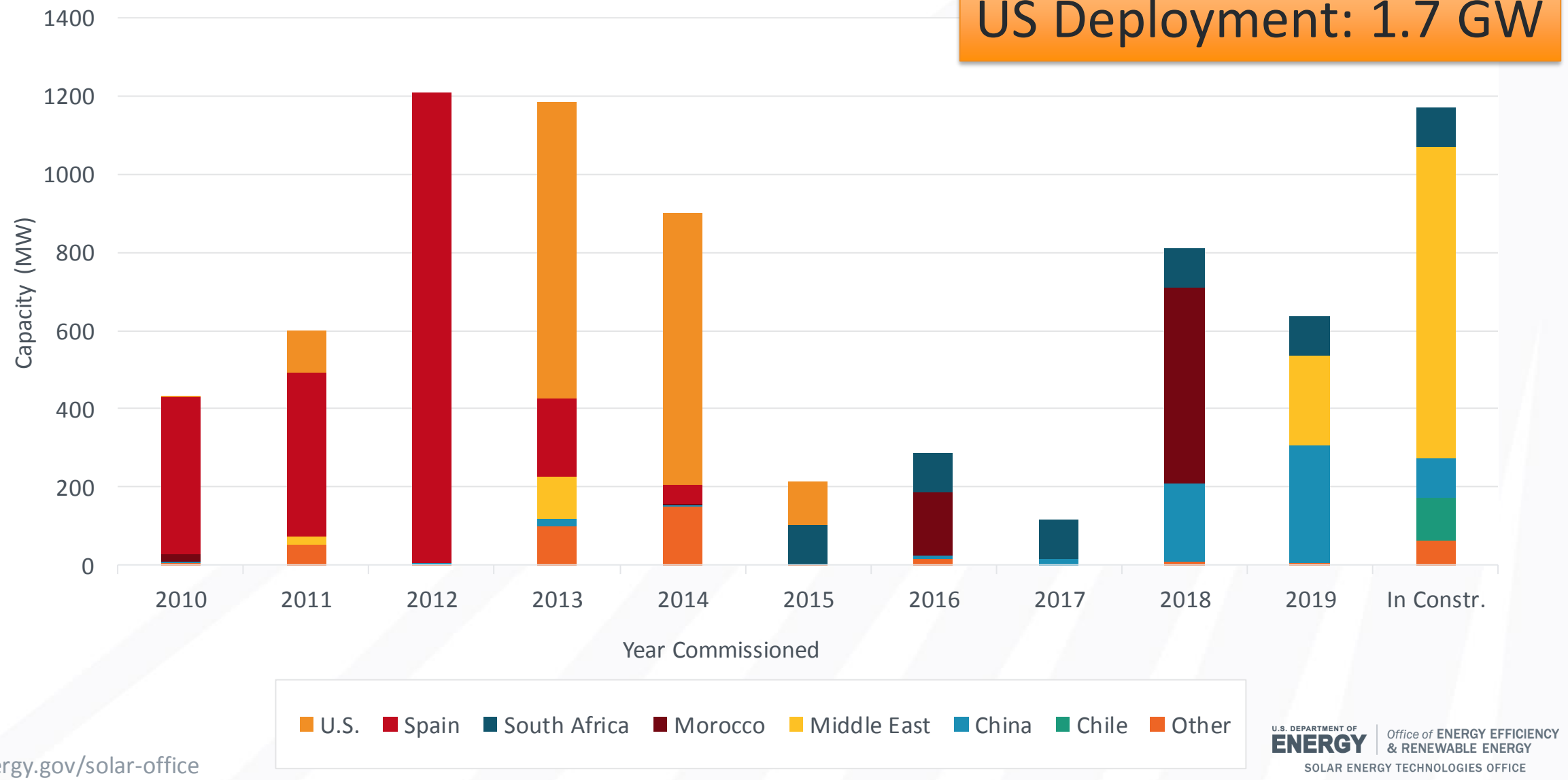
Molten Salt Towers with steam rankine cycle (~565 °C)

'Gen 3 CSP': Novel Heat Transfer Media with advanced power cycle (>700 °C) @ 5¢/kWh

1.3 GW of **Towers** operating globally (410 MW under construction)

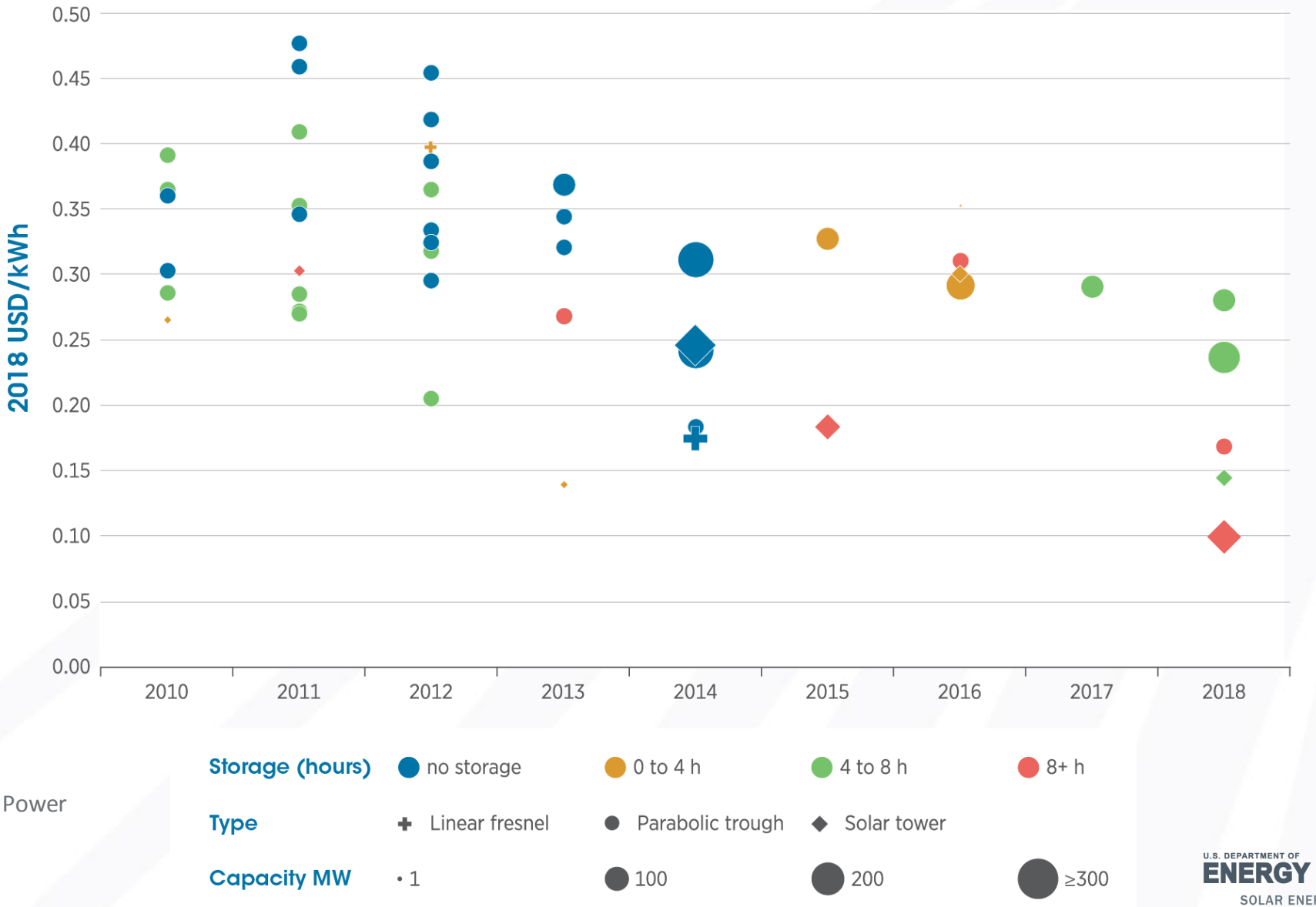
CSP Deployment: 7 GW Worldwide

US Deployment: 1.7 GW



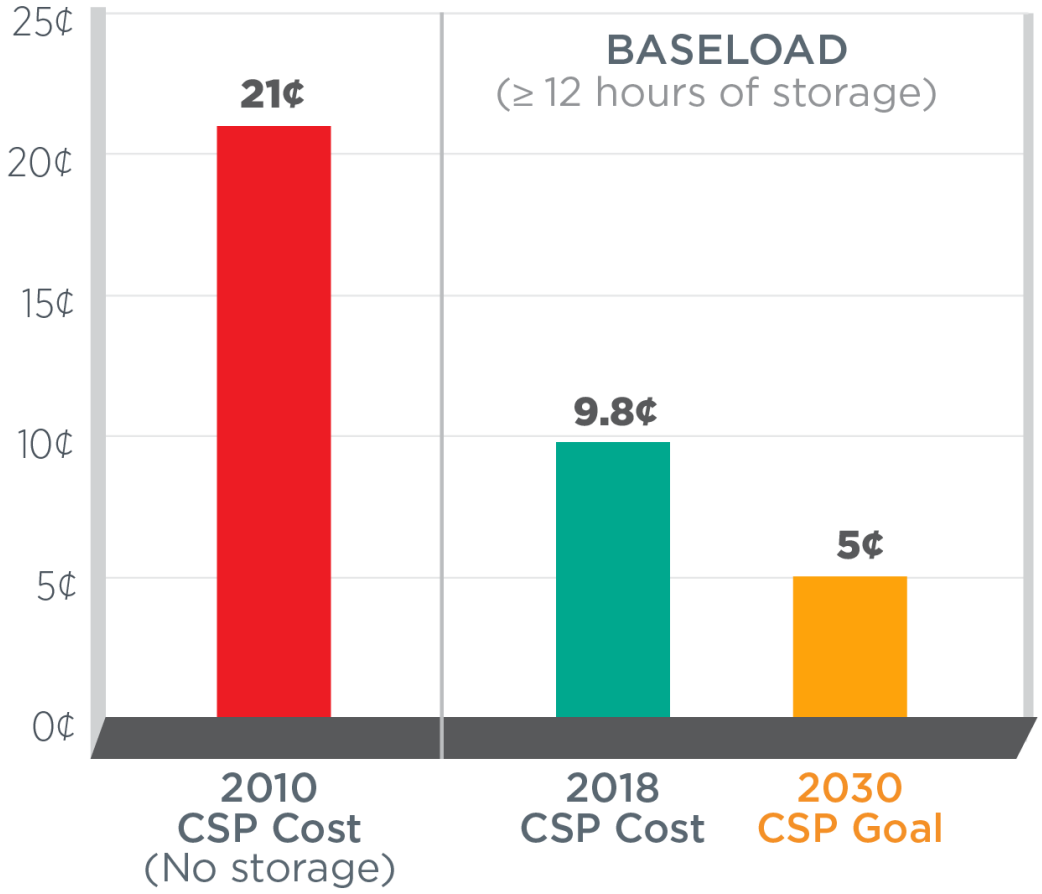
U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY
SOLAR ENERGY TECHNOLOGIES OFFICE

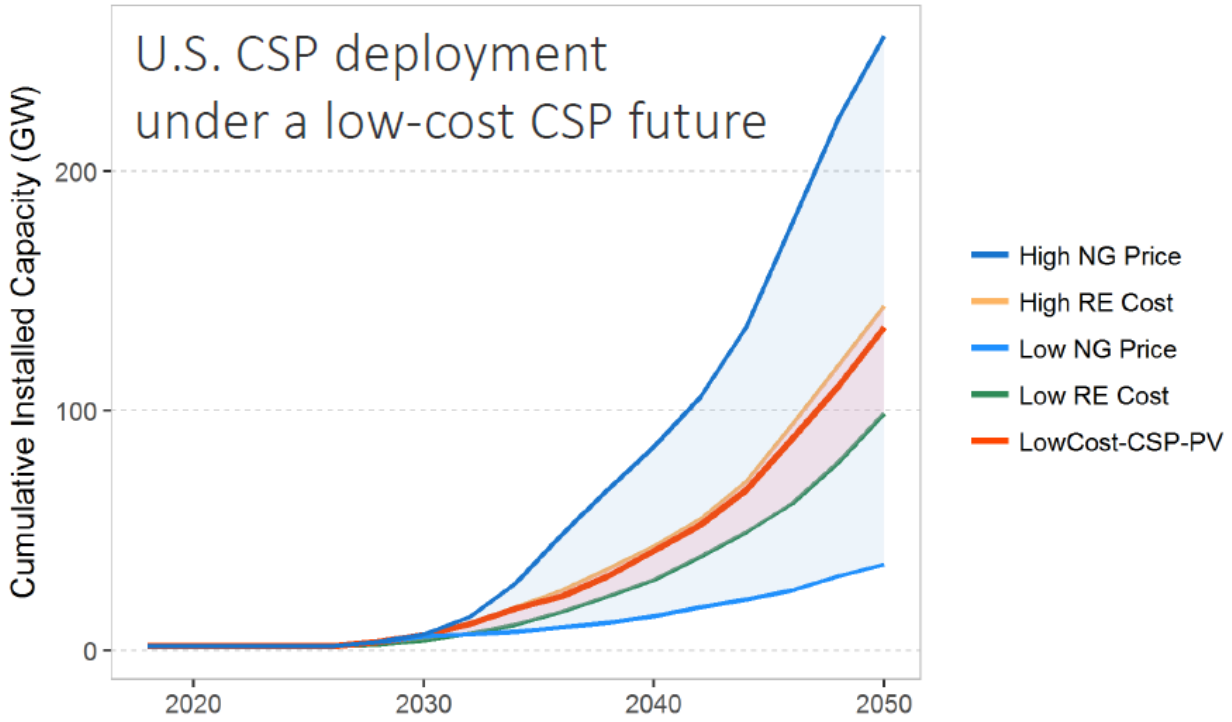
LCOE of Concentrating Solar-Thermal Power (CSP)



Source: IRENA, "Renewable Power Generation Costs in 2018."

2030 LCOE Goals





Murphy, et al. **2019**, NREL/TP-6A20-71912

SOLAR ENERGY TECHNOLOGIES OFFICE

CSP R&D Virtual Workshop Series

- Autonomous, Integrated Heliostat Field & Components – **October 20th, 2020**
- Next Generation Receivers – **October 29th, 2020**
- Unlocking Solar Thermochemical Potential – **November 12th, 19th, December 3rd, 2020, 11am – 2pm ET**
- Pumped Thermal Energy Storage Innovations – **November 17th, 2020, 1-5pm ET**
- CSP Performance and Reliability Innovation – **December 10th, 2020, 11am – 2pm ET**

*Slides and workshop summaries will be posted here:

https://bit.ly/CSP-workshops

SETO Goals

SETO CSP Program:

Strategy and Planning
Outreach and Communication
Strengthen Analysis Capability
Impact with Near-Term Results

Program Strategy

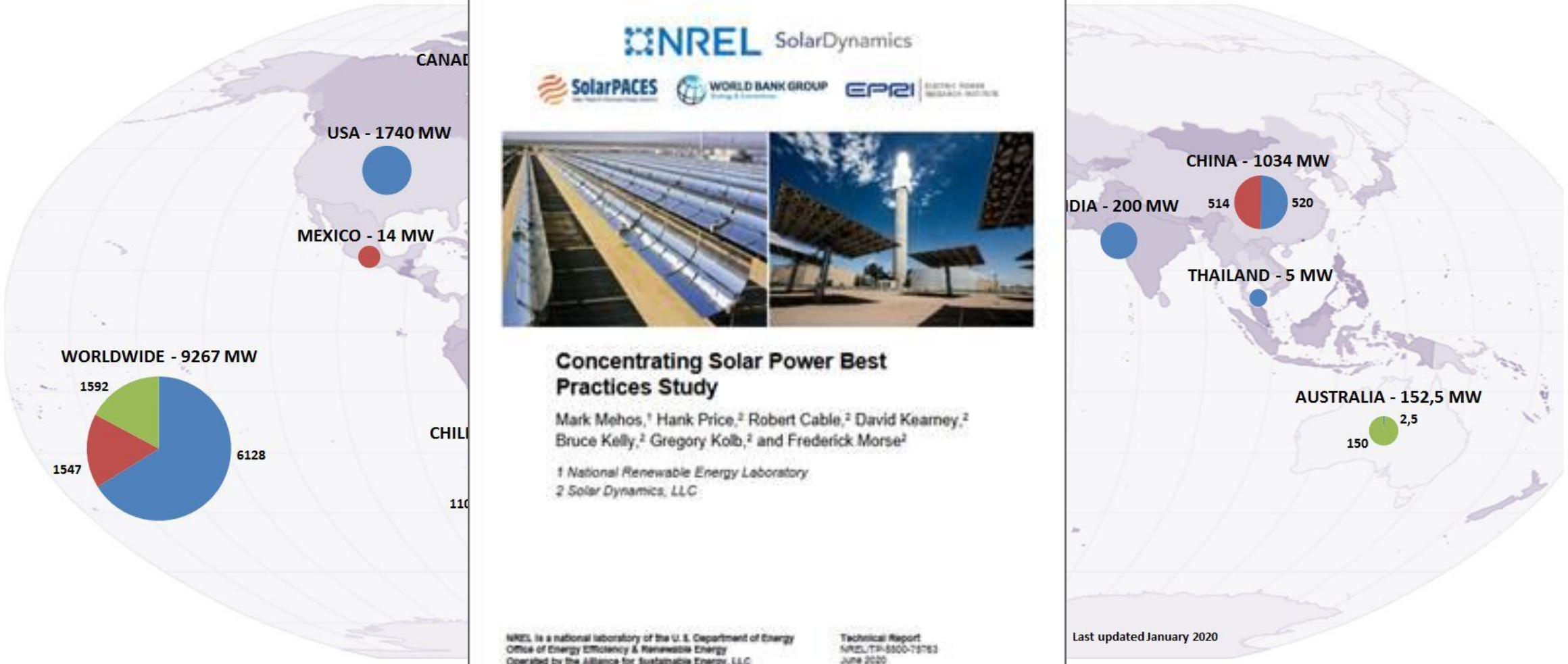
Technology Analysis

SOLUTIONS

CSP Industry:

Benchmark Performance
Best Practices Information
Design and Operation Tools
Solutions for Industry

Best Practices Study on the Global CSP Fleet



NREL SolarDynamics

SolarPACES WORLD BANK GROUP EPRI

Concentrating Solar Power Best Practices Study

Mark Mehos,[1] Hank Price,[2] Robert Cable,[2] David Kearney,[2] Bruce Kelly,[2] Gregory Kolb,[2] and Frederick Morse[2]

1 National Renewable Energy Laboratory
2 Solar Dynamics, LLC

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

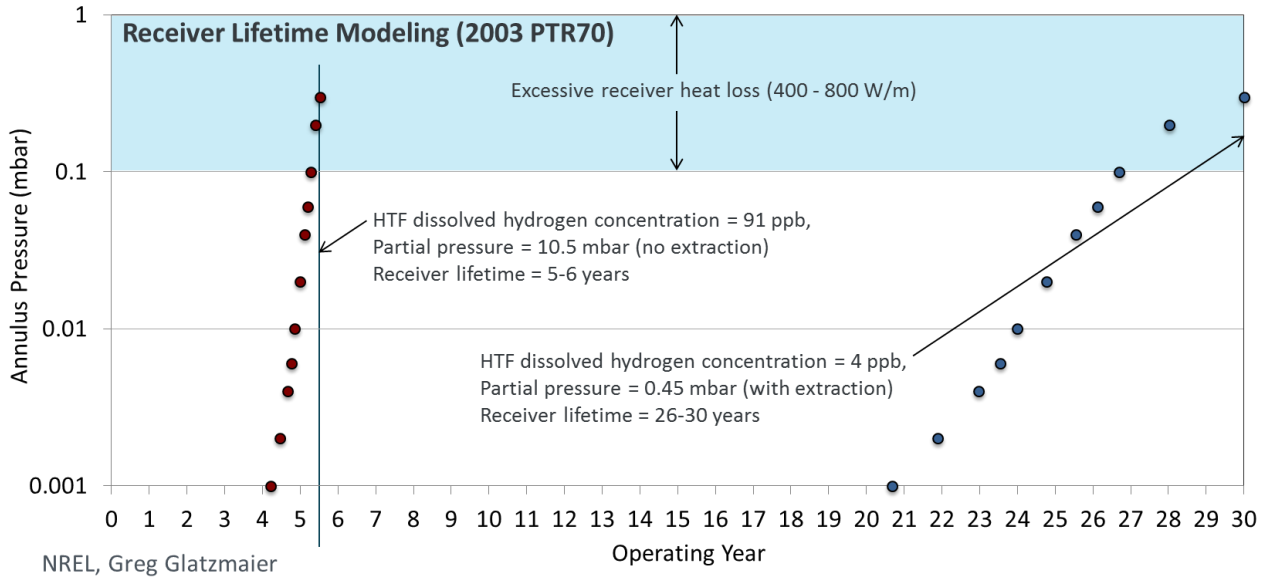
This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-5500-75763
June 2020

SETO Research for CSP System Reliability

- SETO seeks innovations to ensure the reliability of CSP technologies and cross-cutting metrology and analysis.
- SETO's focus on high-temperature (above 700°C) CSP technologies may also be relevant to lower temperature systems, like molten-nitrate-salt-based systems with steam Rankine power cycles.
- These innovations may be applied cost-effectively to improve the capital costs, operating costs, or performance of existing commercial CSP technologies.



Agenda

Time	Session
11:00AM– 11:10AM	**Introduction and Workshop Overview** Avi Shultz, *DOE Program Manager, Concentrating Solar Power* Mark Lausten, *Technology Manager, Concentrating Solar Power*
11:10AM– 11:35AM	**Panel – CSP Best Practices Study** Mark Mehos, *NREL* Hank Price, *Solar Dynamics* Bob Cable, *Consultant, former Acciona Plant Manager NSO* Greg Kolb, *Consultant, former Distinguished Member of SNL*
11:35AM– 12:15PM	**Innovations for CSP Performance and Reliability** Panel and Audience Question and Answer
12:15 PM	**Closing Remarks**

Best Practices Study

~Our Panelists~

Mark Mehos

NREL

Hank Price

Solar Dynamics

Bob Cable

CSP Expert/Consultant

Greg Kolb

Kolb Consultants

Agenda

Time	Session
11:00AM– 11:10AM	**Introduction and Workshop Overview** Avi Shultz, *DOE Program Manager, Concentrating Solar Power* Mark Lausten, *Technology Manager, Concentrating Solar Power*
11:10AM– 11:35AM	**Panel – CSP Best Practices Study** Mark Mehos, *NREL* Hank Price, *Solar Dynamics* Bob Cable, *Consultant, former Acciona Plant Manager NSO* Greg Kolb, *Consultant, former Distinguished Member of SNL*
11:35AM– 12:15PM	**Innovations for CSP Performance and Reliability** Panel and Audience Question and Answer
12:15 PM	**Closing Remarks**

Guided Q&A

Plant Modeling

- Performance modelling and plant controls have are challenging for complex CSP systems, including properly accounting for start-ups, shutdowns, thermal energy storage management, power generation, and maintenance planning. What do these models need to accomplish in order to accurately evaluate annual thermo-economic performance?
    - Real-time operation? Transient behavior? Off design performance? Equipment sizing?
    - Performance Test Correction curve development? Reduce administrative tasks? Maintenance planning?
- What opportunities exist for closed loop automation systems to be implemented in a CSP facility?
- To what extent should plant operating logic be made standard versus field developed?

Guided Q&A

Plant Operations and Training

- What opportunities exist for SETO to support the development of an appropriately-trained workforce for CSP plant operations, including improved operator training ?
- What is the opportunity for SETO to support the development of non-proprietary tools to help train achieve optimal CSP plant operation?

Standard Designs and Specifications

- What design features should be developed and analyzed to address some common and problematic failure mechanisms in molten salt tanks, such as floor buckling, tank leakage, overpressure, and soil desertification?
- What design calculations, codes, or standards should be developed or implemented to prevent future tank failure issues?
- What other opportunities exist for SETO to support the development of non-proprietary technical specifications for future use by CSP developers, EPCs, and owners?

Guided Q&A

Innovations for Nitrate Salt Plants

For high-temperature Gen3 CSP applications, researchers and industry are developing pumps, valves, coatings, and bearings for 700°C applications, and TES research has explored technologies such as internal insulation and foundation design, which may be useful for molten nitrate salt tanks as well.

- What technologies exist to reduce the capital and labor cost of internal insulation for hot molten nitrate salt tanks to support the DOE cost target of $15/kWh for the entire system?
- Can technologies developed for high temperatures be applied to existing 550°C and 290°C pumps increase reliability and lower capital cost?
- Can the knowledge gained from the design of molten chloride receivers at ≥700°C be used to improve the design of molten nitrate receivers?

Significant research has been pursued on microchannel heat exchangers for salt-to-sCO_2 applications, which may be extended to molten nitrate-to-steam heat exchangers.

- Given that there have been some challenges with heat exchanger leaks in molten-nitrate-salt-based plants, what opportunities exist to develop steam generators at ≥200 MWth scale that meet acceptable cost targets and lifetime expectations?

Concluding Remarks

Thank You!

Look for slides posted at:
https://www.energy.gov/eere/solar/concentrating-solar-thermal-power-research-and-development-virtual-workshop-series