



**SOLAR ENERGY
TECHNOLOGIES OFFICE**
U.S. Department Of Energy

PORTFOLIO REVIEW

2018



SOLAR ENERGY
TECHNOLOGIES OFFICE
U.S. Department Of Energy

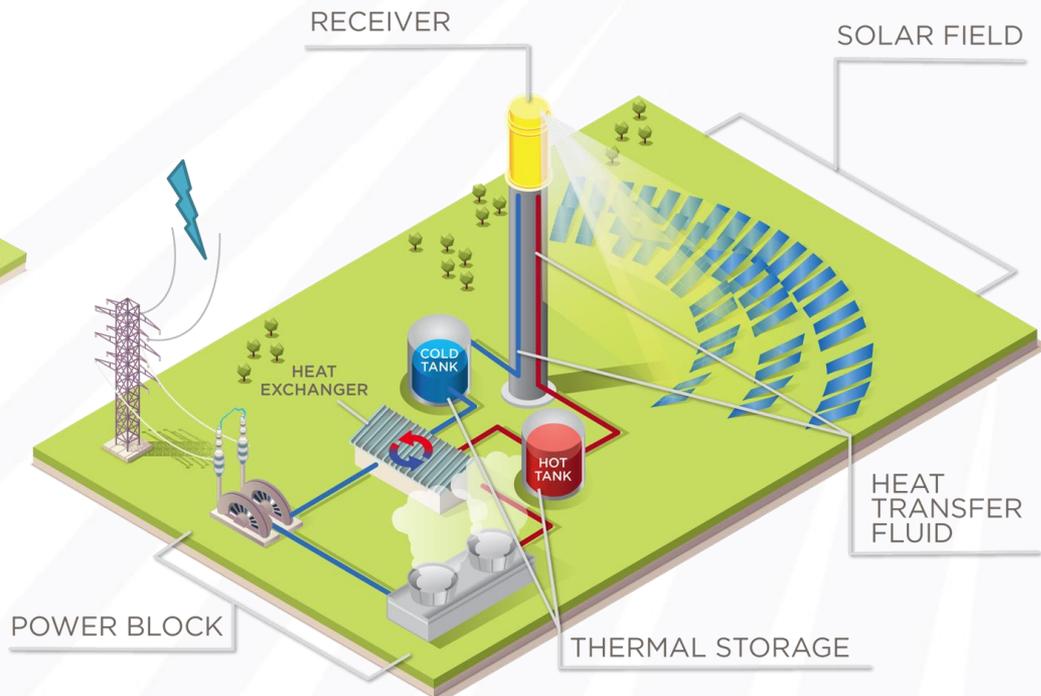
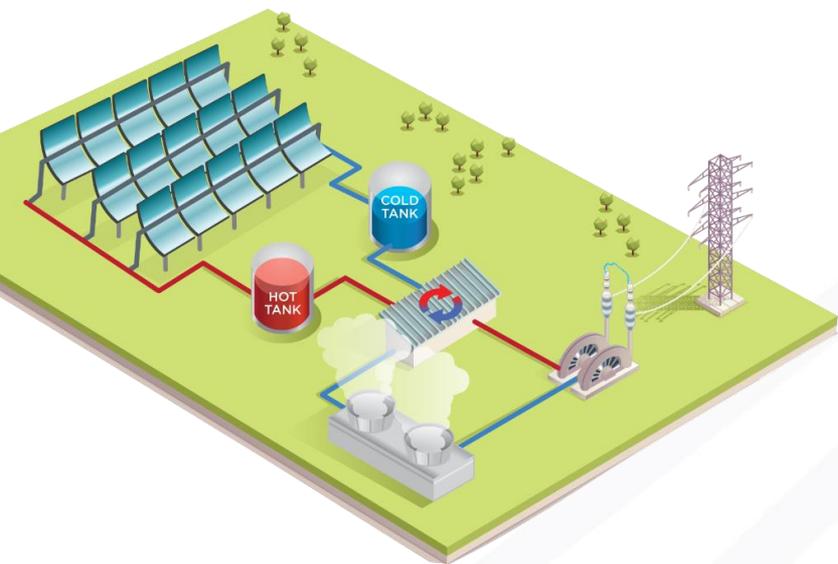
2018 SETO Portfolio Review

Concentrating Solar Thermal Power Subprogram

SETO Portfolio Review
February, 2018

Dr. Avi Shultz, Program Manager (Acting)

CSP with Storage is Solar Energy On-Demand



CSP is Deployed Worldwide



4.8 GW CSP deployed globally

1.8 GW CSP deployed in the U.S.

0.4 GW CSP deployed in the U.S. *with storage*

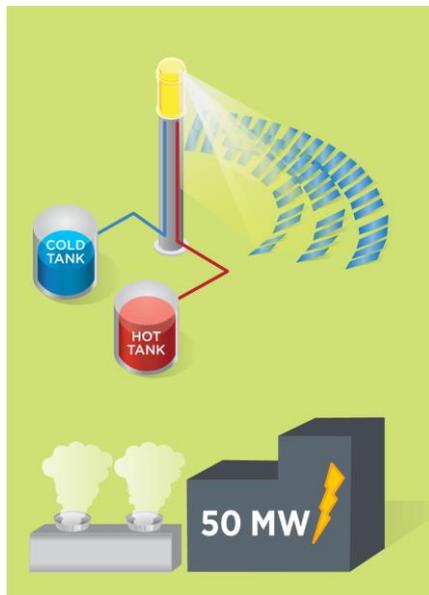
Since 2016 CSP's share of electricity generation:

- 1% of California
- 2% of Spain

CSP: Flexible Designs for an Evolving Grid

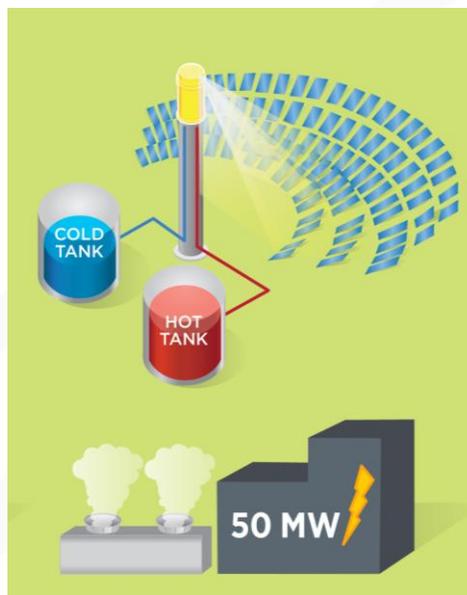
'Peaker'

(≤6 hours of storage)



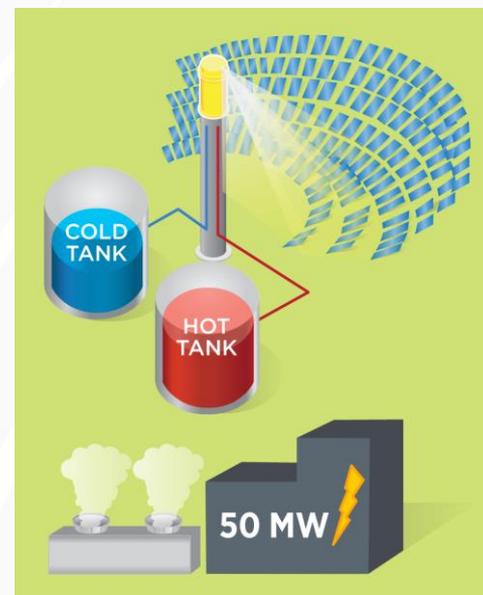
'Intermediate'

(9 hours of storage)



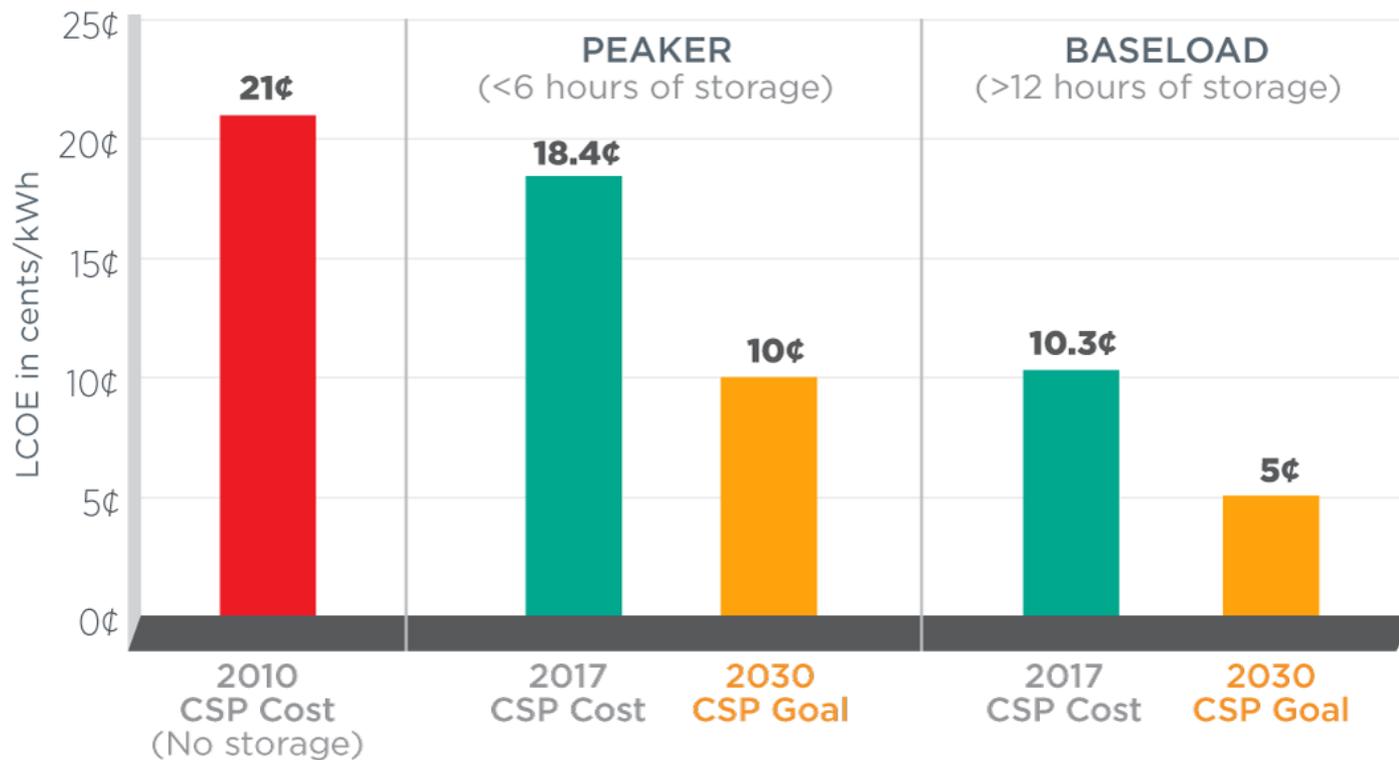
'Baseload'

(≥12 hours of storage)



By choosing the size of the solar field and thermal energy storage, the same CSP technology can be configured to meet evolving demands of the future grid

2030 Levelized Cost of Electricity Targets



CSP Program Technical Targets

O&M TARGET

\$40/kW-yr plus \$3/MWh

 5¢/kWh

RECEIVER

Thermal Efficiency $\geq 90\%$
Lifetime $\geq 10,000$ cyc
Cost $\leq \$150/\text{kW}_{\text{th}}$
Exit Temp $\geq 720^\circ\text{C}$

SOLAR FIELD

Cost $\leq \$50/\text{m}^2$
Lifetime ≥ 30 yrs
Annual Efficiency $\geq 55\%$
Concentration Ratio ≥ 1000 Suns

COLD TANK

HOT TANK

HEAT TRANSFER MEDIUM

POWER BLOCK

Net Cycle Efficiency $\geq 50\%$
Dry Cooled
Cost $\leq \$900/\text{kW}_e$

THERMAL STORAGE

Energy Efficiency $\geq 99\%$
Exergetic Efficiency $\geq 95\%$
Cost $\leq \$15/\text{kWh}_{\text{th}}$
Power Cycle Inlet Temp $\geq 720^\circ\text{C}$

Thermally Stable $\geq 800^\circ\text{C}$
Compatible with Rec. Performance
Compatible with TES Performance

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
- Manufacturing and automation
- Sensors and control

Gen3 CSP: Raising the Temperature of Solar Thermal Systems

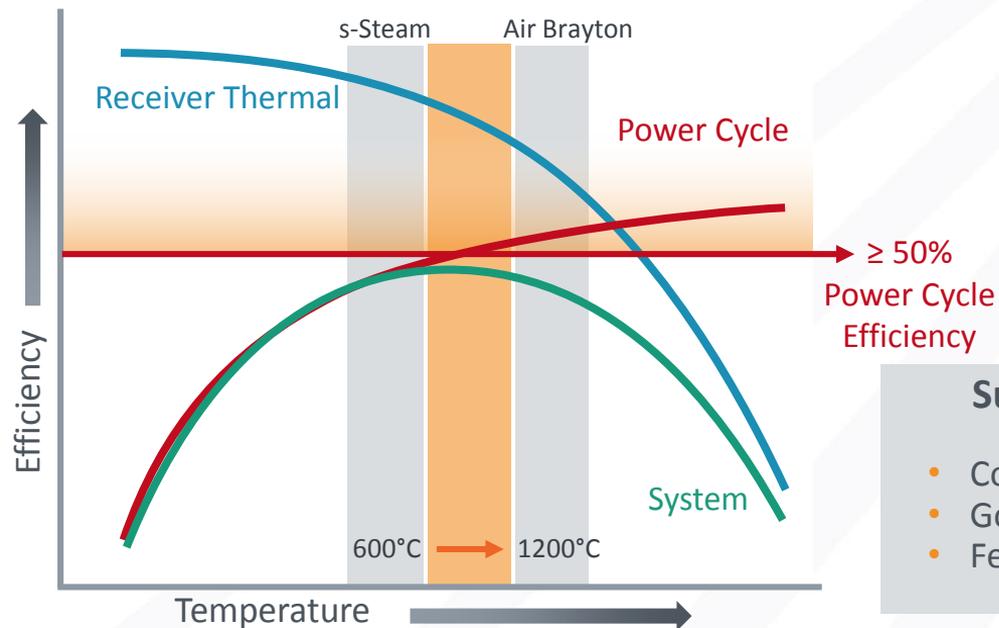
$$\eta = 1 - \frac{T_C}{T_H}$$

Thermal Pathway	Primary Challenges
Liquids	Reliable corrosion management with advanced molten salts
Solids	High-efficiency transfer of heat in and out of particles
Gas	Integrating low-density gases with cost-effective thermal energy storage



Next Generation CSP will Leverage Next Generation Power Cycles

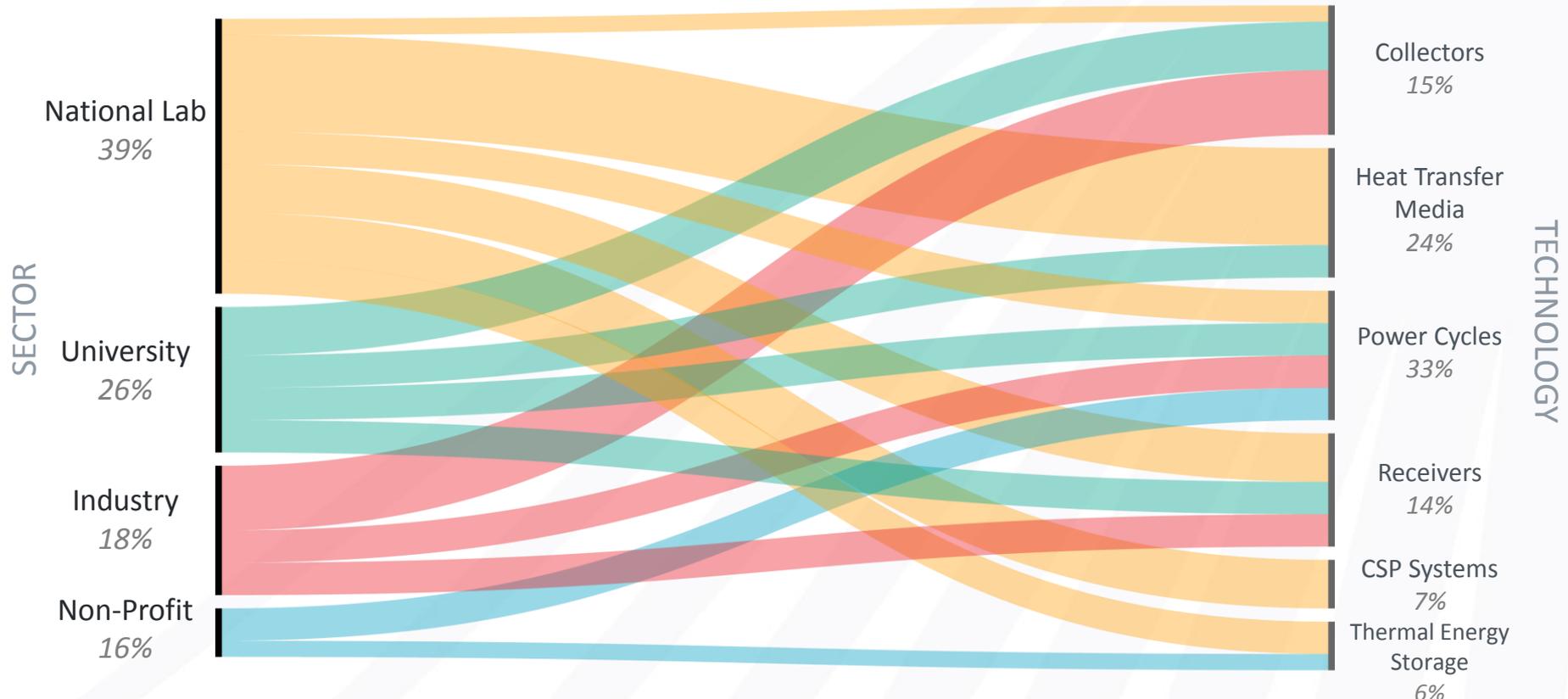
$$\eta_{\text{Cycle}} = 1 - \frac{T_C}{T_H} \text{ vs. } Q_{\text{Radiative}} \propto T^4$$



Supercritical CO₂ is a dense, compressible fluid:

- Compact turbomachinery
- Good compatibility with dry cooling
- Fewer loss mechanisms and parasitics

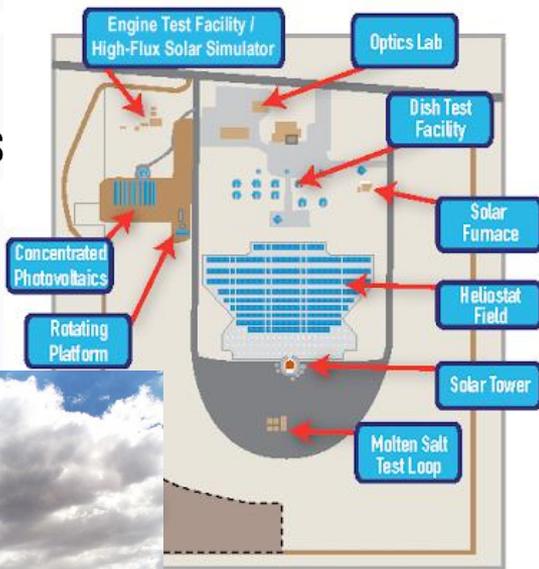
CSP Awardee Breakdown by Funding



Lab Core Capabilities



National Solar Thermal Test Facility (NSTTF)



System Advisor Model

Version 2017.9.5

SAM 2017.9.5

Choose a performance model, and then choose from the available financial models.

- | | |
|-------------------------------------|---|
| Photovoltaic (detailed) | PPA single owner (utility) |
| Photovoltaic (PVWatts) | PPA partnership flip with debt (utility) |
| High concentration PV | PPA partnership flip without debt (utility) |
| Wind | PPA sale leaseback (utility) |
| Biomass combustion | |
| Geothermal | |
| Solar water heating | |
| Generic system | |
| CSP parabolic trough (physical) | |
| CSP parabolic trough (empirical) | |
| CSP power tower molten salt | |
| CSP power tower direct steam | |
| CSP linear Fresnel molten salt | |
| CSP linear Fresnel direct steam | |
| CSP dish Stirling | |
| CSP generic model | |
| CSP integrated solar combined cycle | |
| Process heat parabolic trough | |
| Process heat linear direct steam | |

Starting up...please wait



SETO CSP Team

Technology Managers



Mark Lausten, PE
On contract from
Allegheny S&T



Levi Irwin, PhD
On contract from Mantech



Matt Bauer, PhD
On contract from Mantech



Andru Prescod, PhD, MBA
On contract from Mantech
energy.gov/solar-office



**Rajgopal 'Vijay'
Vijaykumar, PhD**



Sam Bockenbauer, PhD
On detail from the Office of Policy

Technical Project Officer



Christine Bing, MBA, PMP

Financial Project Analyst Operations



Patty Clark, MBA, PMP
On contract from Allegheny S&T



Meisha Baylor
On contract from Red Horse

CSP Review Overview

- Monday, February 12
 - 11am – 12pm: CSP Subprogram Strategy and Vision
 - 1pm – 2pm: Tech-to-Market CSP Overview
 - 2pm – 3pm: Research Guided by Technoeconomic Analysis
- Tuesday, February 13
 - 9:30am: CSP Awardee Plenary – Hank Price, Solar Dynamics
 - 11am – 12pm: From Concept to Prototype
 - 1pm – 2pm: Designing for System and Component Interfaces
 - 2pm – 3pm: Materials Challenges and Opportunities