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

SOLAR ENERGY TECHNOLOGIES OFFICE

Concentrating Solar-thermal Power Research and Development Program

UC Solar Thermal Symposium
November 15, 2019; Davis, California

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Solar Energy Technologies Office, US Department of Energy

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Solar Energy Technologies Office

WHAT WE DO

The Solar Energy Technologies Office funds early-stage research and development in three technology areas: photovoltaics, concentrating solar power, and systems integration with the goal of improving the **affordability**, **reliability**, and **performance** of solar technologies on the grid.

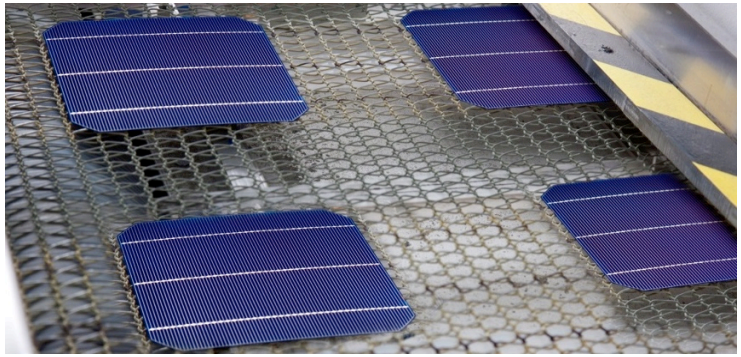
HOW WE DO IT

Cutting-edge **technology development** that drives U.S.s leadership and supports a growing and skilled workforce.

Research and development to **address integration of solar** to the nation's electricity grid.

Relevant and objective technical information on solar technologies to stakeholders and decision-makers.

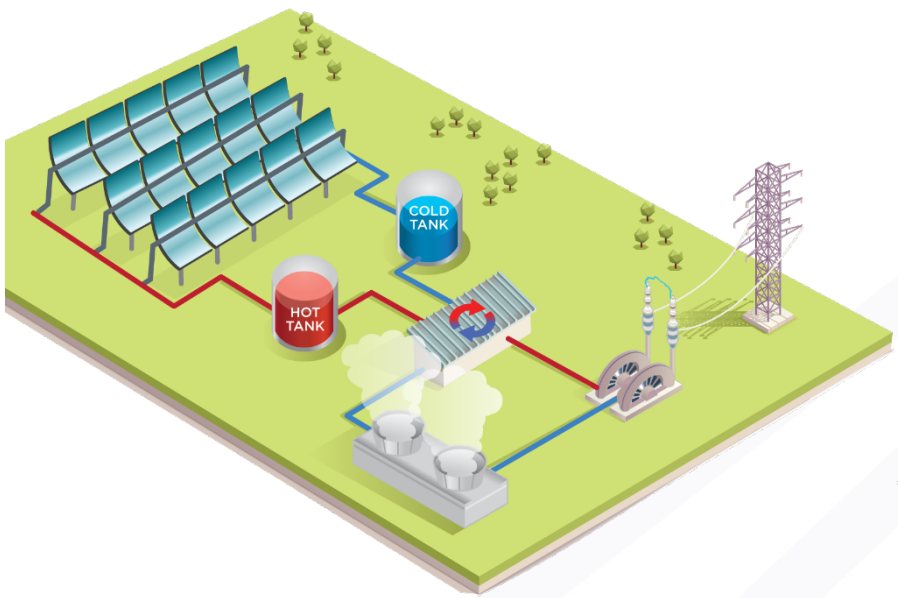
Solar Technologies: Photovoltaics, Concentrating Solar-Thermal Power

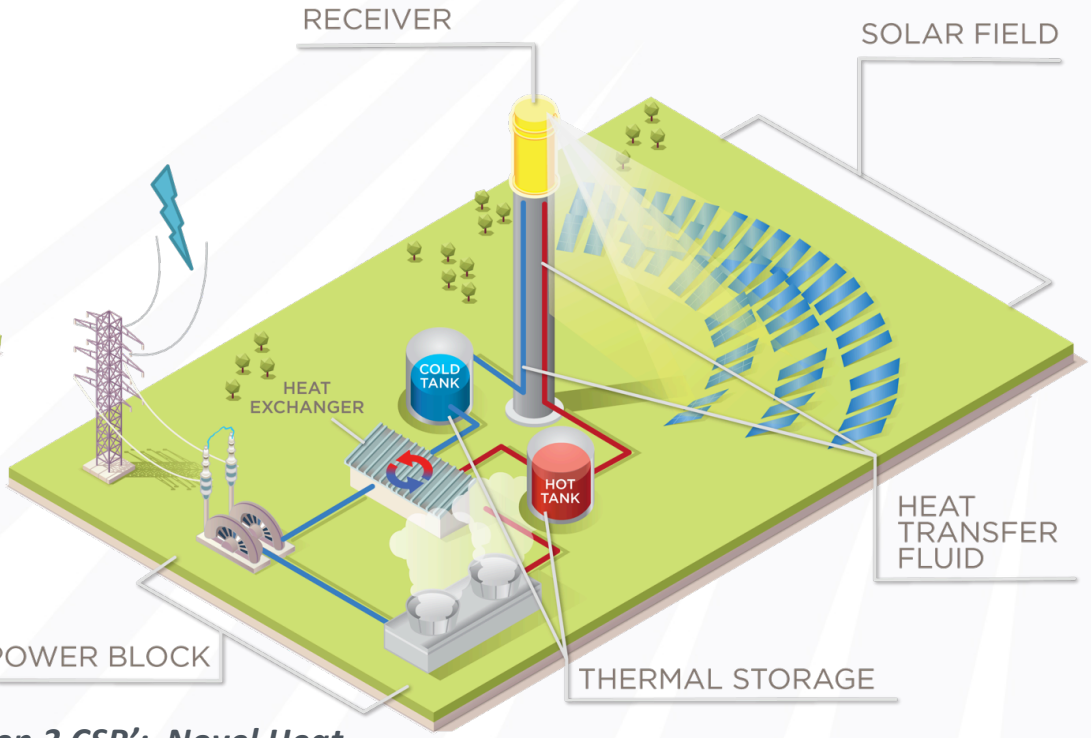


Photovoltaic (PV) technologies absorb energy from sunlight and convert it directly into electricity through a semiconductor material, such as silicon. Individual PV panels/modules are connected together to make large arrays.

Concentrating solar-thermal power (CSP) technologies use mirrors to reflect and concentrate sunlight onto a receiver where it is collected and converted into heat. This heat energy can be stored and used to produce electricity whenever it is needed.

CSP with Storage is Solar Energy On-Demand





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***

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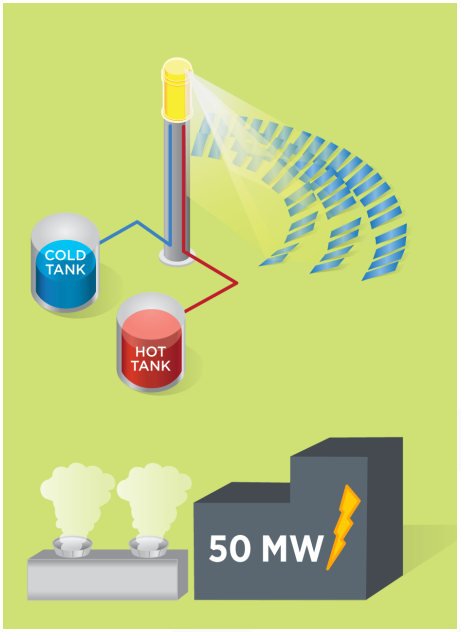
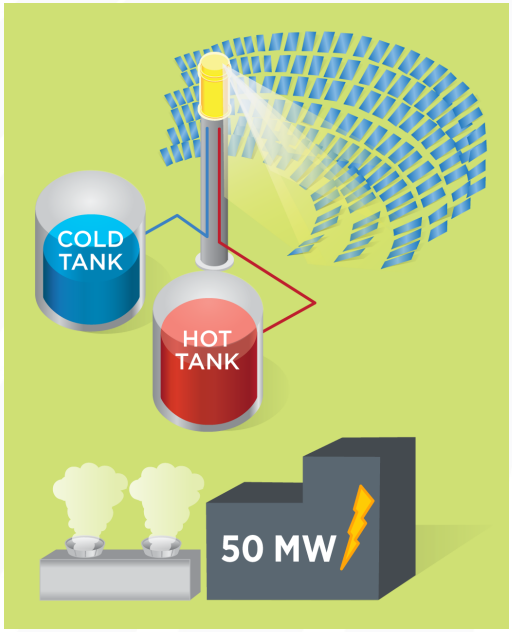
Thermal Energy Storage Enables Flexible Designs

'Peaker'
(≤6 hours of storage)

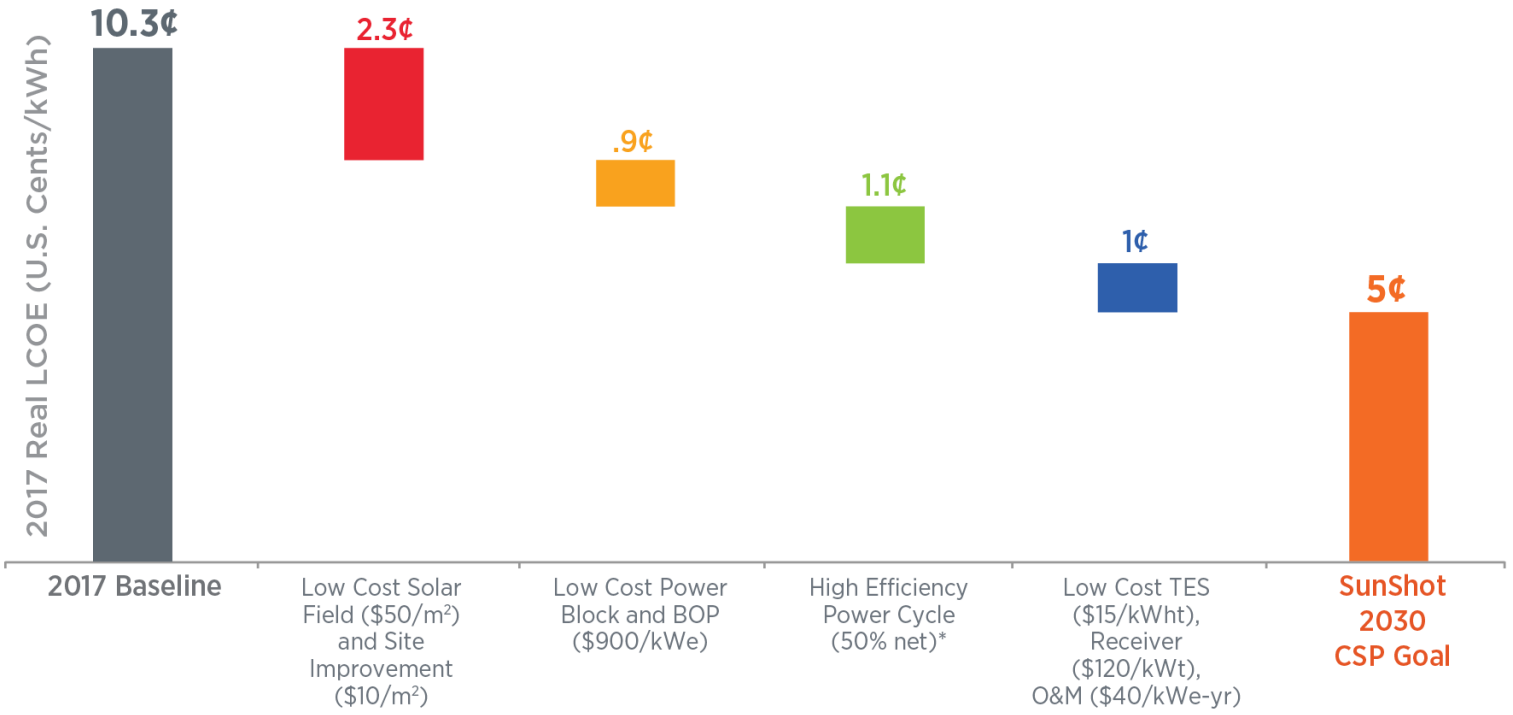


'Baseload'
(≥12 hours of storage)



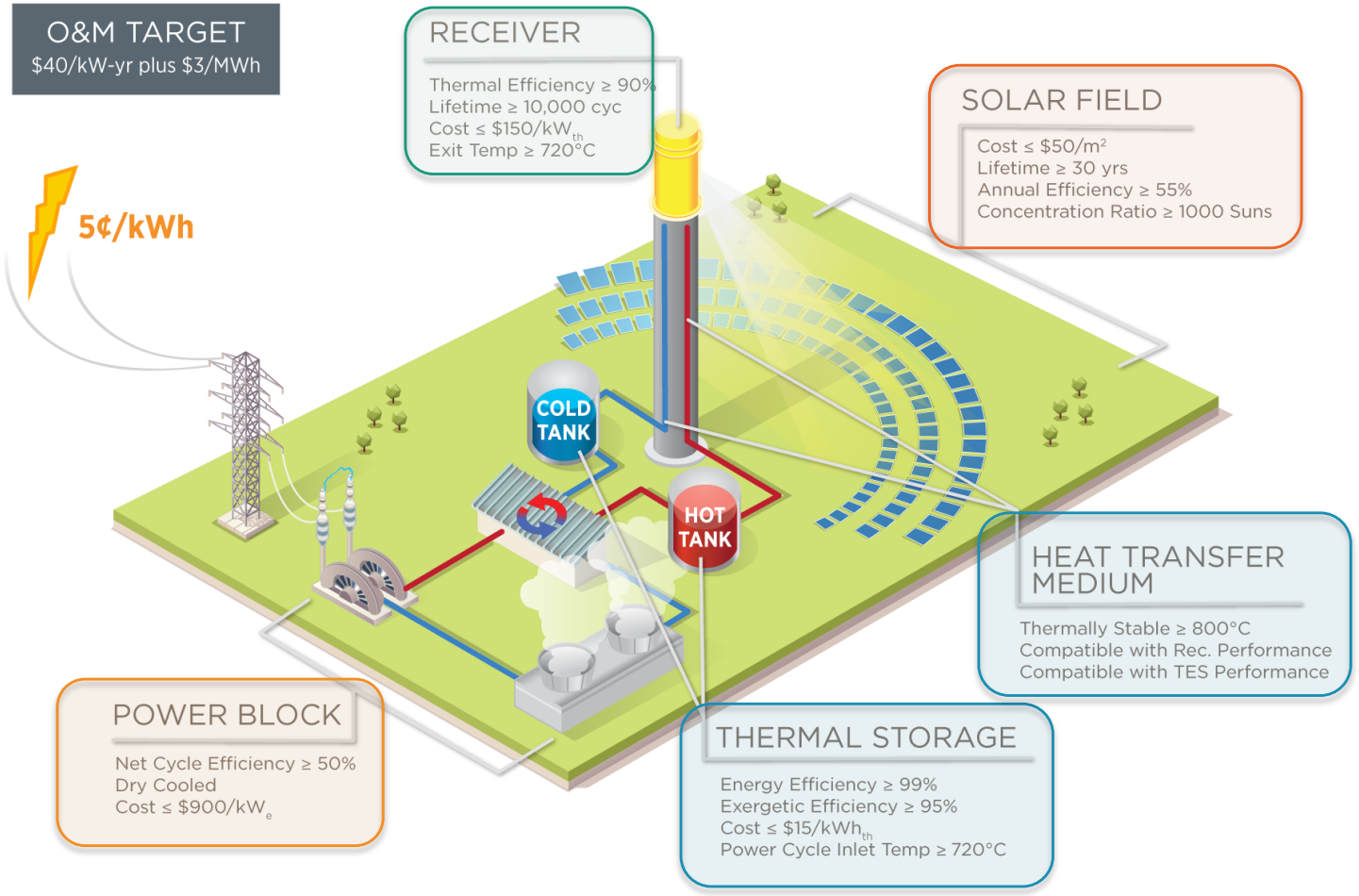
By choosing the size of the solar field and thermal energy storage, the same CSP technology can be configured to meet evolving demands of the grid

A Pathway to 5 Cents per KWh for Baseload CSP



*Assumes a gross to net conversion factor of 0.9

CSP Program Technical Targets



Competitive Programs

$30M	FY19 SETO FOA (2019)
$22M	FY18 SETO FOA (2018)
$21M	Solar Desalination (2018)
$22M	FY19-21 National Lab Call (2018)
$70M	Gen3 CSP Systems (2018)
$15M	Gen3 CSP Lab Support (2018)
$9M	COLLECTS (2016)
$32M	CSP: APOLLO (2015)
$29M	CSP SuNLaMP (2015)
$1.4M	SolarMat II (2014)
$10M	CSP: ELEMENTS (2014)
$1.1M	SunShot Incubator (Recurring)
$4M	PREDICTS (2013)
$2M	SolarMat (2013)
$10M	CSP-HIBRED (2013)
$27M	National Lab R&D (2012)
$10M	SunShot MURI (2012)
$56M	CSP SunShot R&D (2012)
$0.5M	BRIDGE (2012)
$62M	CSP Baseload (2010)

CSP Program Technical Targets

O&M TARGET
$40/kW-yr plus $3/MWh

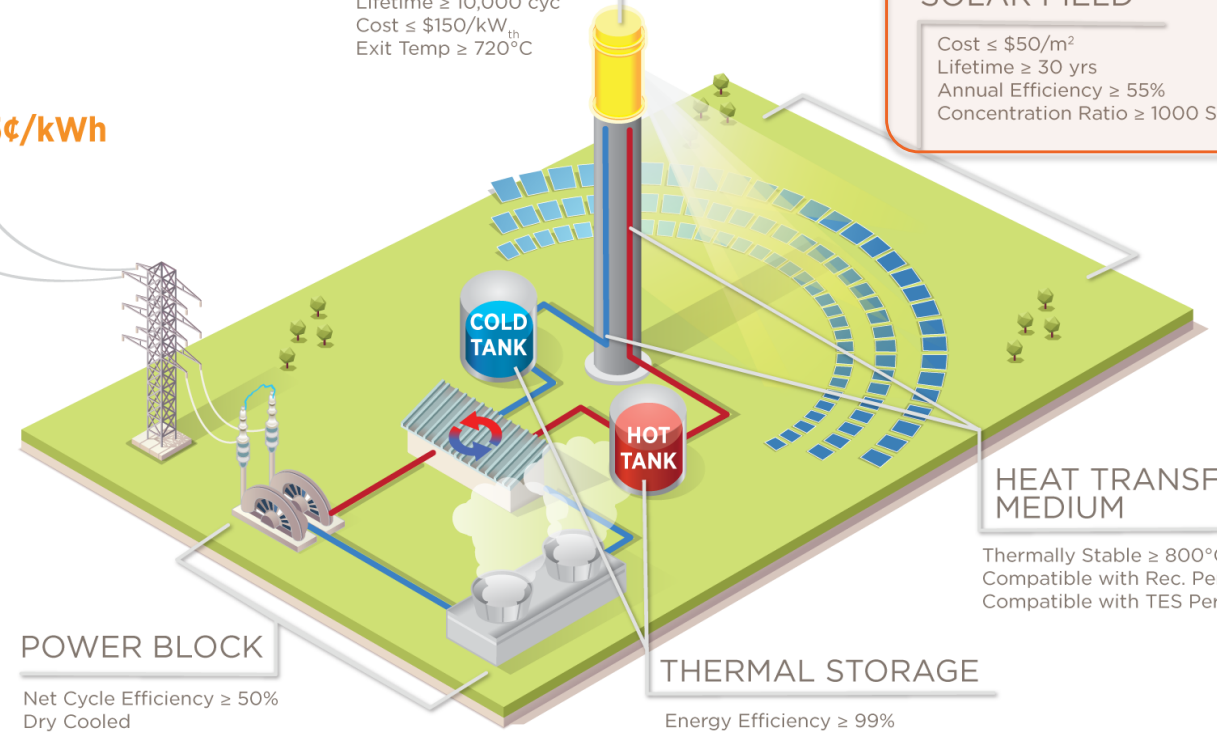
5¢/kWh

RECEIVER

Thermal Efficiency ≥ 90%
Lifetime ≥ 10,000 cyc
Cost ≤ $150/kW$_{th}$
Exit Temp ≥ 720°C

SOLAR FIELD

Cost ≤ $50/m^2
Lifetime ≥ 30 yrs
Annual Efficiency ≥ 55%
Concentration Ratio ≥ 1000 Suns



HEAT TRANSFER MEDIUM

Thermally Stable ≥ 800°C
Compatible with Rec. Performance
Compatible with TES Performance

POWER BLOCK

Net Cycle Efficiency ≥ 50%
Dry Cooled
Cost ≤ $900/kW$_e$

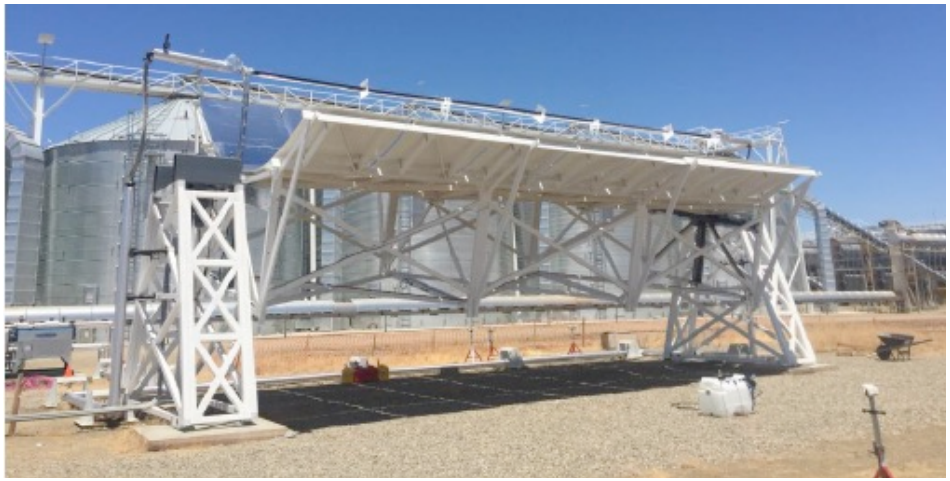
THERMAL STORAGE

Energy Efficiency ≥ 99%
Exergetic Efficiency ≥ 95%
Cost ≤ $15/kWh$_{th}$
Power Cycle Inlet Temp ≥ 720°C

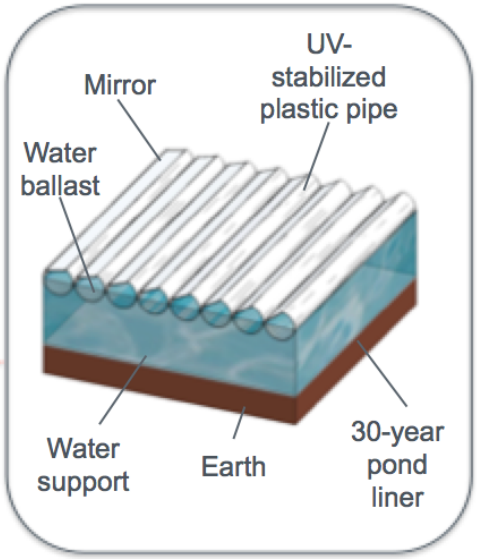
Concentrating Optics for Lower Levelized Energy Costs

Traditional Designs, 'New' Low-Cost Materials for Solar Thermal Process Heat

SUNVAPOR
RENEWABLE PROCESS HEAT



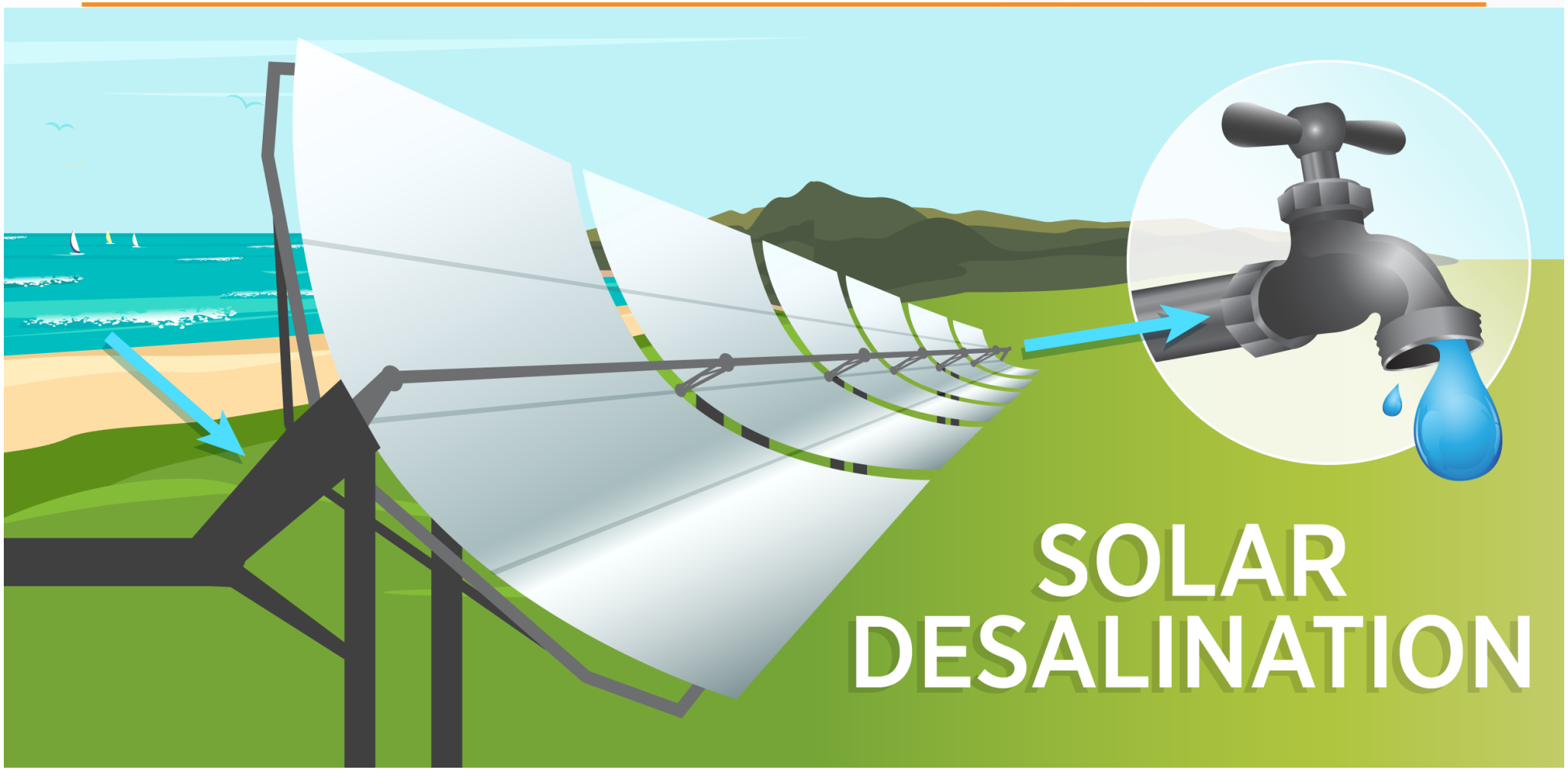
- Sunvapor is prototyping wood-based 'green' parabolic trough collectors (GPTC) with thermal energy storage to generate solar steam



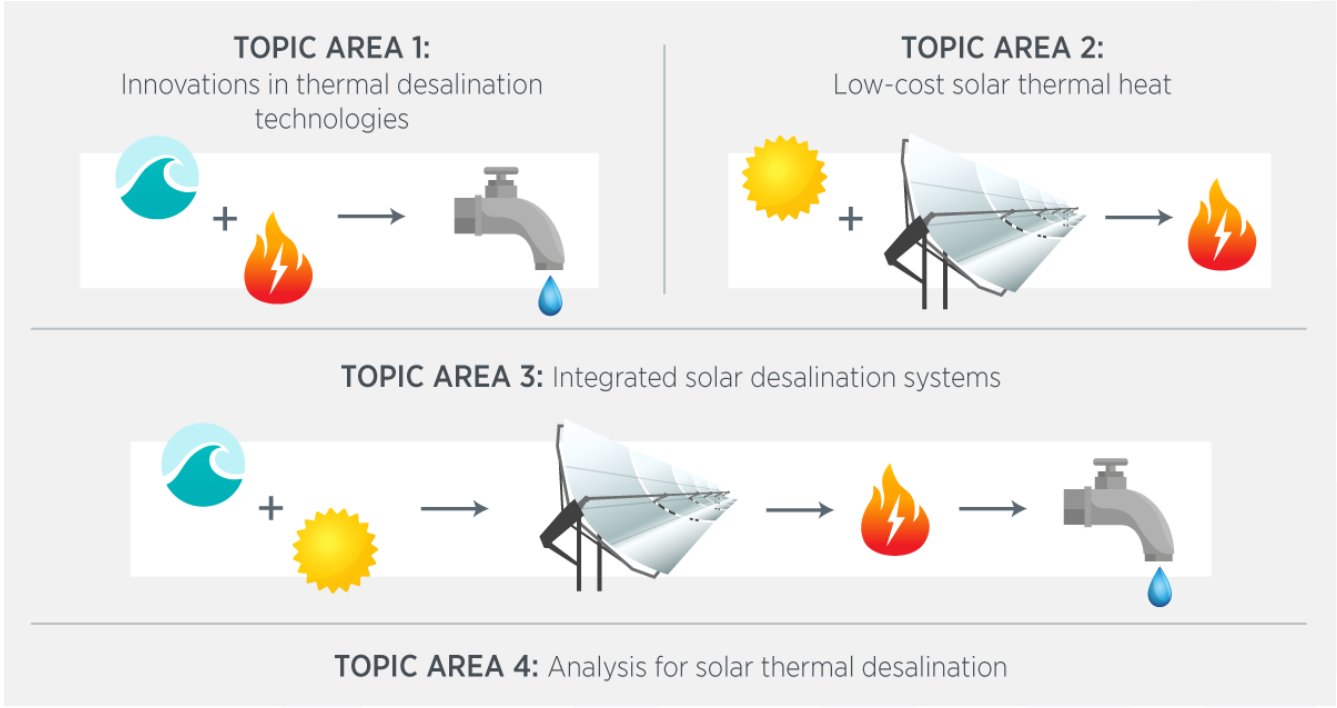
Hyperlight® Energy

In April 2019, Hyperlight awarded a $6.5M project to generate process steam for a Saputo Cheese production facility

Solar Desalination Funding Program



Solar Desalination Funding Program



- Total federal funds awarded: $21,000,000
- 14 selected projects began in Fall 2018
- Technical targets:
  - Increase thermal efficiency of desalination
  - Reduce Levelized Cost of Heat to ≤ 1¢/kWh_t
  - Achieve Levelized Cost of Water ≤ 50¢/m^3

Levelized Cost of Heat for Solar Thermal Desalination

LCOH Cost Target for Solar Field, 10 Hours of Storage

Component	Current (NREL 2015)	Large ($0.50/m^3)	Small ($1.50/m^3)
LCOH ($/kWh$_{thermal}$)	**0.027**	**0.01**	**0.015**
Total direct cost ($/m^2)	350	110	180
Site Prep ($/m^2)	30	20	10
HTF Receiver ($/m^2)	70	30	50
Collector ($/m^2)	170	45	100
O&M ($/m^2)	15	5	5
Storage ($/kWh$_{thermal}$)	20	10	10

CATEGORY	PRIME	PROJECT TITLE	PI	AWARD
Topic 1	UCLA	Energy Where it Matters: Delivering Heat to the Membrane/Water Interface for Enhanced Thermal Desalination	David Jassby	$1,995,249
	U. Illinois – Urbana-Champaign	Ultra-Compact and Efficient Heat Exchanger for Solar Desalination with Unprecedented Scaling Resistance	Anthony Jacobi	$1,584,349
	U. N. Dakota	Supercritical Treatment Technology for Water Purification	Michael Mann	$1,999,999
	GreenBlu	High-Efficiency, Zero Liquid Discharge, Multiple-Effect Adsorption Distillation	Howard Yuh	$1,600,000
	Fraunhofer CEI	Solar-Driven Desalination by Membrane Distillation using Ceramic Membranes	Jeffrey McCutcheon	$800,000
	Lawrence Berkeley NL	Direct Solar-Thermal Forward Osmosis Desalination of Produced Waters	Robert Kostecki	$800,000
	Oregon State U.	Zero Liquid Discharge Water Desalination Process using Humidification-Dehumidification in a Thermally Actuated Transport Reactor	Bahman Abbasi	$2,000,000
Topic 2	SkyFuel	SkyTrough Vacuum Membrane: An Extreme Low-Cost Solar-Thermal Collector for Desalination	Nathan Schuknecht	$1,598,814
	Sunvapor	Solar Steam on Demand	Philip Gleckman	$1,500,000
	Advanced Cooling Tech.	Loop Thermosyphon Enhanced Solar Collector	Fangyu Cao	$1,500,000
	UC Merced	Low-Cost Dispatchable Heat for Small-Scale Solar-Thermal Desalination Systems	Roland Winston	$1,081,793
Topic 3	Natural Energy Lab. of Hawaii Authority	Hawaii SunShot Desal Project	Gregory Barbour	$1,928,238
	Rice University	Low-Cost Desalination using Nanophotonics-Enhanced Direct Solar Membrane Distillation	Qilin Li	$1,700,000
Topic 4	Columbia University	GIS-Based Graphical User Interface Tools for Analyzing Solar-Thermal Desalination Systems and High-Potential Implementation Regions	Vasilis Fthenakis	$972,797

American Made Challenge: Solar Desalination

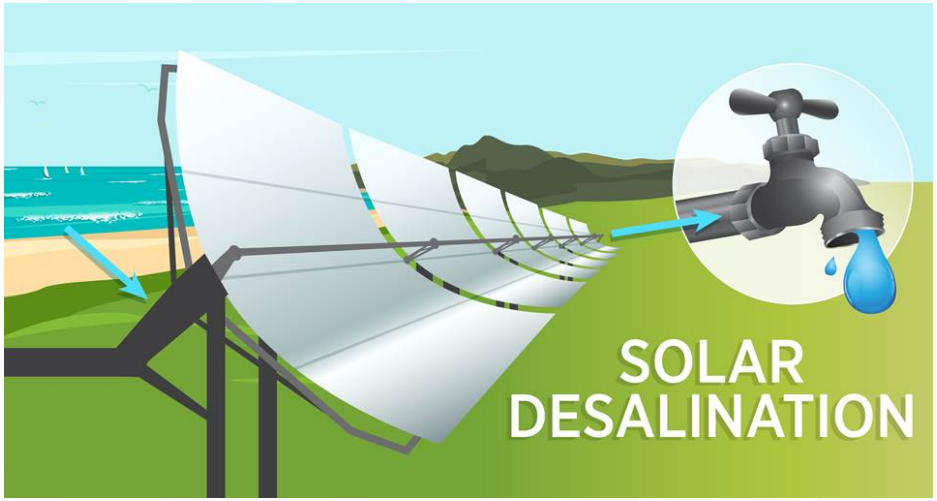
Objective: Demonstrate cost-effective solar thermal desalination technologies for early markets and applications.

Prize Structure and Features:

- Multi-phase competition, progressing from concept design through demonstration
- Will seek to connect technology developers with test facilities (government and private)

Metrics:

- Thermal Efficiency ($kWh_{thermal}/m^3$ product water)
- Recovery Ratio ($V_{product\ water}/V_{brine}$)
- Continuous Operations (Continuous hours of water production)
- Solar Efficiency (kWh_{solar}/m^3 product water)
- Projected levelized cost of heat (LCOH) and water (LCOW)



- ***Multi-million dollar prize was announced on September 25, 2019***
- ***Detailed prize rules to be released in early 2020***

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Questions?

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