U.S. DEPARTMENT OF ENERGY

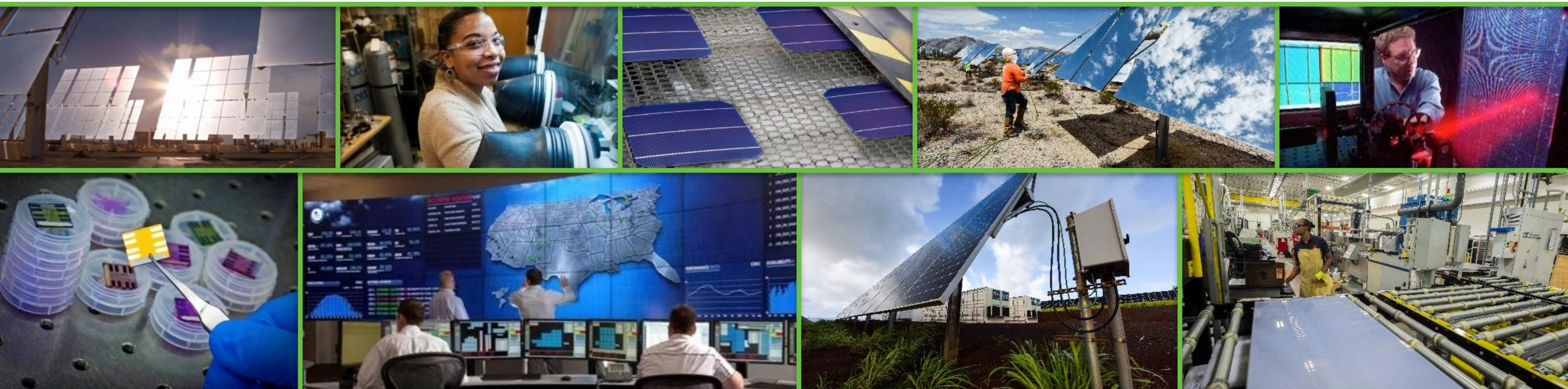
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

February 15th, 2024

CSP Solar Receivers and Reactors Virtual Workshop

Matthew Bauer, DOE Program Manager

Solar Energy Technologies Office



Problem Statement and Workshop Goals

Problem Statement

- ❑ Concentrated Solar Thermal applications are limited by the conditions and control of converting light to thermal energy.
  - Gen3 CSP (for a 700°C sCO_2 Power Cycle)
  - Commercial CSP Systems
  - Other Novel Electricity Generation embodiments
  - Long Duration Thermochemical Energy Storage
  - Solar Reactors for Fuels, Chemicals, and other uses
  - Low and High Temperature Solar Industrial Process Heat

Workshop Goal

- ❑ Enable CSP stakeholders to engage with SETO and CSP Receiver experts to share insights and lessons learned for developing and de-risking existing and new solar receiver systems.
  - All statements made by panelists and participants are personal reflections, based on their experiences.
- ❑ Consider framework for advancing receiver innovations from idea to commercial adoption.
- ❑ Provide feedback to the DOE by responding directly to our Request for Information
  - https://www.energy.gov/eere/solar/request-information-receivers-and-reactors-concentrating-solar-thermal-power-plants-and

Solar Energy Technologies Office

Our mission is to accelerate the advancement and deployment of solar technology in support of an equitable transition to a decarbonized economy no later than 2050, starting with a decarbonized power sector by 2035.

To achieve this mission, solar energy must:

- Be **affordable** and **accessible** for all Americans
- Support the **reliability**, **resilience**, and **security** of the grid
- Create a sustainable industry that **supports job growth**, **manufacturing**, and the **circular economy** in a wide range of applications

Driving Toward Administration Decarbonization Goals

- **Reduce hardware and soft costs** of solar electricity **for all Americans** to enable an affordable carbon-free power sector by 2035.
- Enable inverter-based technologies to provide essential grid services and black start capabilities while demonstrating the **reliable, resilient and secure operation of a 100% clean energy grid**.
- **Accelerate solar deployment and associated job growth** by opening new markets, reducing regulatory barriers, providing workforce training, and growing U.S. manufacturing.
- **Center energy justice** by reducing environmental impacts, removing barriers to equitable solar access, and supporting a diverse and inclusive workforce.
- **Support a decarbonized industrial sector** with advanced concentrating solar-thermal technologies and develop affordable renewable fuels produced by solar energy.

CSP affects communities.

The **Justice40 initiative** states that "40 percent of the overall benefits" of certain federal investments flow to disadvantaged communities. These investments include those for clean energy and energy efficiency that are allocated by SETO.

Links: Overview of Justice40 initiative; Executive Order 14008

DOE Concentrating Solar-Thermal Power Team

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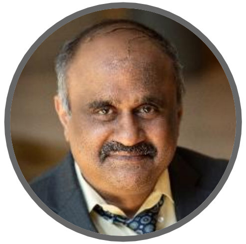


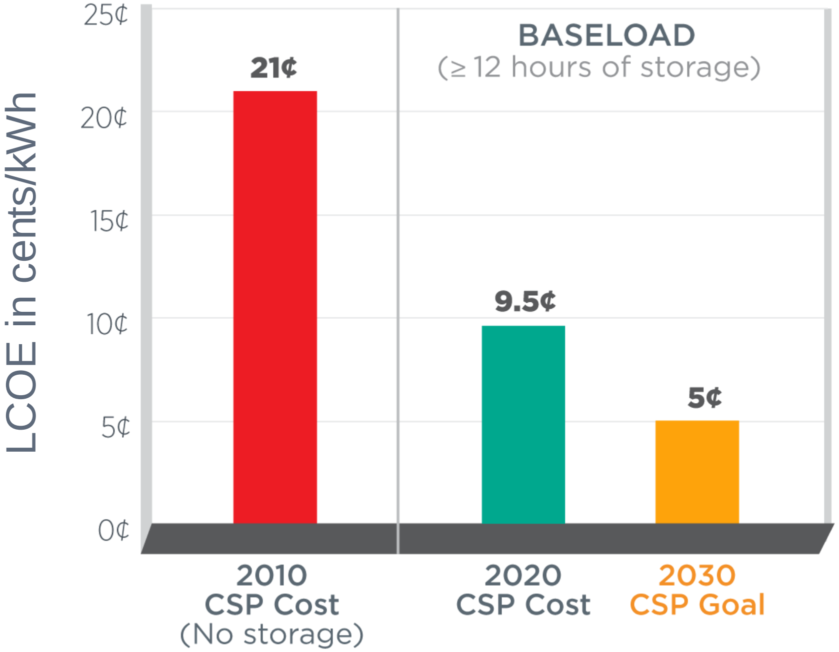
Rajgopal
"Vijay"
Vijaykumar

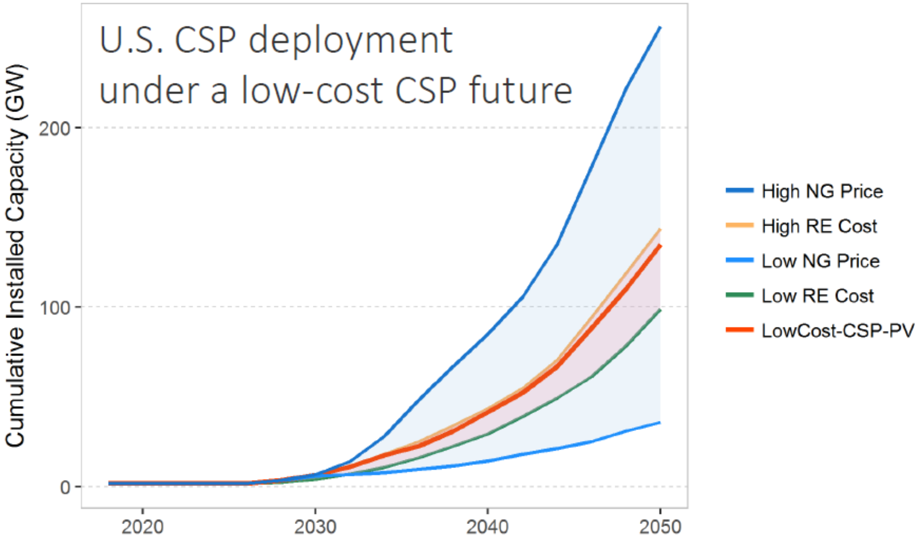
Lindsay
Walter

Gong
Zhou

2030 CSP Goal

The office’s 2030 cost targets for CSP baseload (≥12 hours of storage) plants will help make CSP competitive with other dispatchable generators.



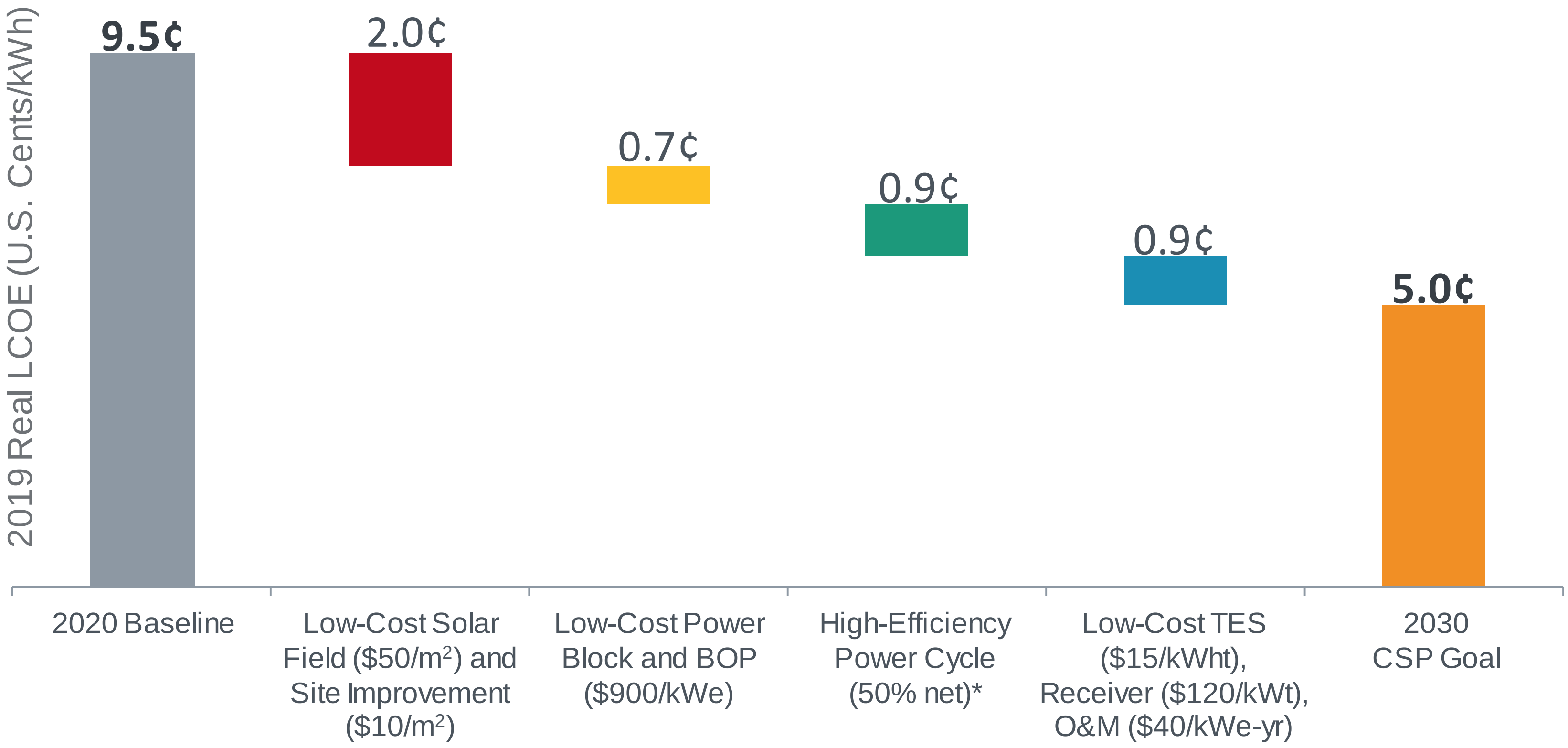


Murphy, et al. **2019**, NREL/TP-6A20-71912

*Levelized cost of energy (LCOE) progress and targets are calculated based on scenarios without federal tax credit or state/local incentives.

Study prior to passage of the Inflation Reduction Act

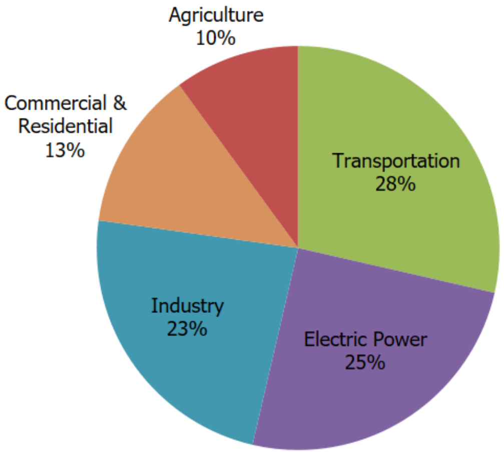
A Pathway To 5¢ per kWh for CSP

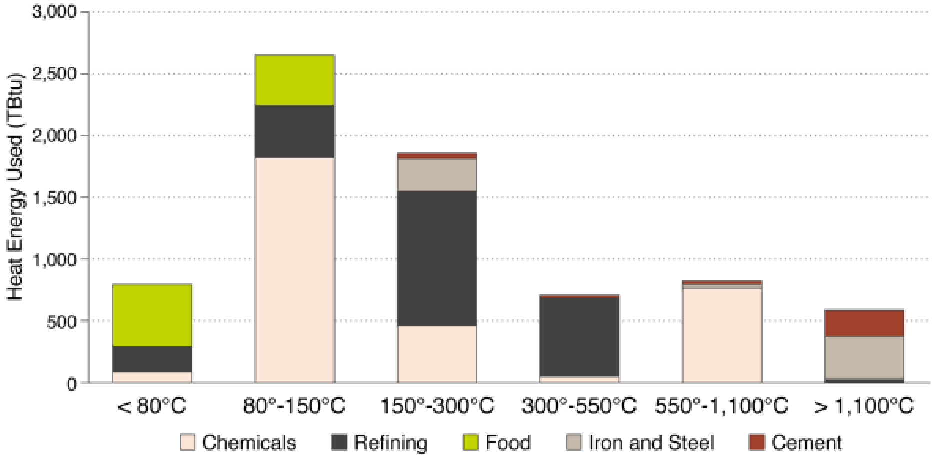


*Assumes a gross to net conversion factor of 0.9


Gen3CSP
Bringing together the people and the pieces for an
INTEGRATED CSP SYSTEM

US Emissions and Energy use beyond Electricity





EPA (2024) Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022. U.S. Environmental Protection 9 Agency, EPA 430-D-24-001.

Colin McMillan, “Manufacturing Thermal Energy Use in 2014,” National Renewable Energy Laboratory, 10.7799/1570008,

DOE Crosscutting Industrial Decarbonization Framework

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Industrial Heat Shot

>85% Lower Emissions

2035

Industrial Decarbonization Pillars

Energy Efficiency	Industrial Electrification	Low-Carbon Fuels, Feedstocks, and Energy Sources (LCFFES)	Carbon Capture, Utilization, and Storage (CCUS)

Success Story: Hawaii Tests the Waters of Carbon-free Desalination

BACKGROUND

- Removing salt from seawater is traditionally expensive, energy-intensive, and disruptive to ecosystems.
- Standard desalination methods use a semipermeable membrane to filter out salt and other contaminants from water through a process called reverse osmosis.

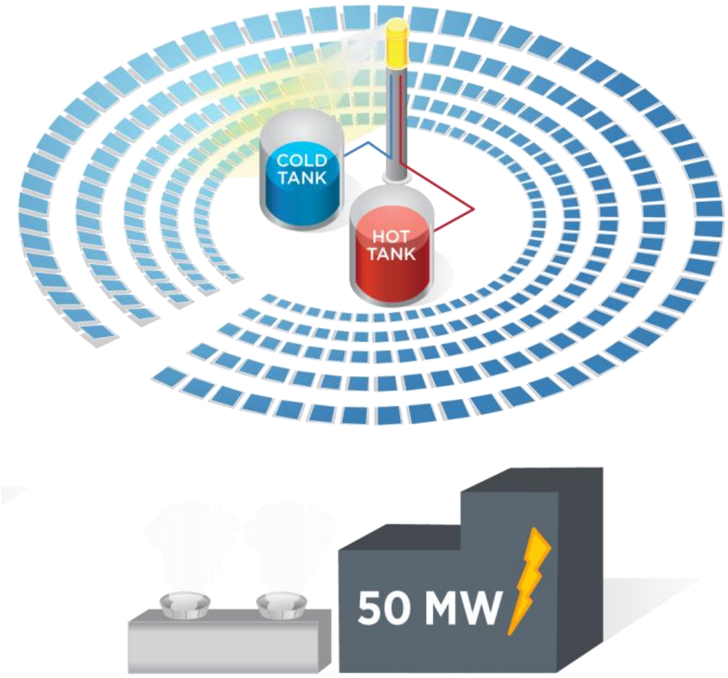
SUCCESS

- Trevi's innovation uses forward osmosis (FO), helps the membranes stay cleaner and last longer without using energy to move the water.
- Trevi and the Natural Energy Laboratory of Hawaii Authority (NELHA) integrated this technology to create a solar desalination plant that produces fresh water from ocean water at low cost.

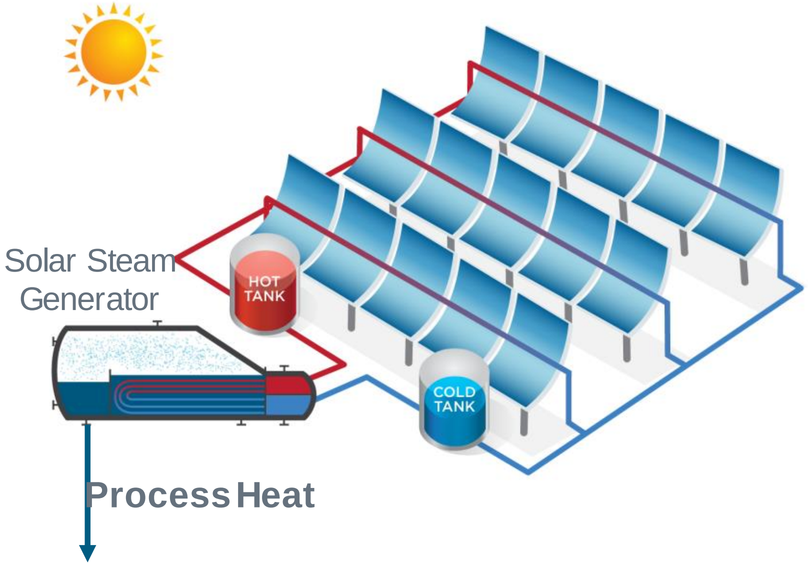
Concentrating Solar-Thermal Technology for Power and Heat-Based Applications

BASELOAD POWER

(≥12 hours of storage)



SOLAR PROCESS HEAT



Thermally-Driven Industrial Processes:

- Desalination
- Enhanced Oil Recovery
- Agriculture and Food Processing
- Fuel and Chemicals Production
- Mining and Metals Processing

Workshop Agenda

Time (EST)	Session
Noon – 12:15 PM	**Welcome and Introduction** Matthew Bauer, DOE Program Manager, Concentrating Solar Power
12:15 PM– 1:15 PM	**Gen3 CSP Particle Systems** Jeremy Sment, Sandia National Laboratories Bill Hamilton, National Renewable Energy Laboratory Matt Carlson and Andrew Oles, Heliogen
1:30 PM– 2:30 PM	**Commercial Receiver Development** Bruce Kelly, Solar Dynamics Joe Coventry, Australian National University Hank Price, Solar Dynamics
2:40 PM – 3:40 PM	**Panel 1: Innovative Receiver Concepts** Jin-Soo Kim, Commonwealth Scientific and Industrial Research Organization Luka Lackovic, German Aerospace Center Gianluca Ambrosetti, Synhelion
3:40 PM – 4:40 PM	**Panel 2: Innovative Receiver Concepts** Reza Sarrafi-Nour, General Electric Research Zhiwen Ma, National Renewable Energy Laboratory Vinod Narayanan, University of California Davis Jeff Halfinger, Ceramic Tubular Products USA

Agenda: Gen3 Particle Systems

12:15 PM -1:15 PM EST

1. G3P3, Jeremy Sment, Sandia National Laboratories
2. Particle-solar flux interactions, Bill Hamilton, National Renewable Energy Laboratory
3. Integrated TESTBED: Matt Carlson & Andrew Oles, Heliogen

Agenda: Commercial Receivers Development

1:30 PM - 2:30 PM EST

1. Nitrate salt receivers: Bruce Kelly, Solar Dynamics

2. Sodium receivers: Joe Coventry, Australian National University

3. Trough Receivers: Hank Price, Solar Dynamics

Agenda: Panel 1 Innovative Receiver Concepts

2:40 PM - 3:40 PM EST

1. Falling particle receiver testing: Jin-Soo Kim, Australian Solar Thermal Institute
2. Development of centrifugal receivers: Luka Lackovic , German Aerospace Center
3. Gas receiver advances: Gianluca Ambrosetti, Synhelion
4. Panel Discussion and Q&A with Audience

Agenda: Panel 2 Innovative Receiver Concepts

3:40 PM - 4:40 PM EST

1. Additively manufactured SiC receiver design for high temperature concentrated solar thermal application: *Reza Sarrafi-Nour*, General Electric Research

2. Light Trapping Receivers: *Zhiwen Ma*, National Renewable Energy Laboratory

3. Microchannel receivers: *Vinod Narayanan*, University of California Davis

4. Ceramic tubes for high temperature receiver applications: *Jeff Halfinger*, Ceramic Tubular Products USA

5. Panel Discussion and Q&A with Audience

Open Request for Information from DOE

https://www.energy.gov/eere/solar/request-information-receivers-and-reactors-concentrating-solar-thermal-power-plants-and

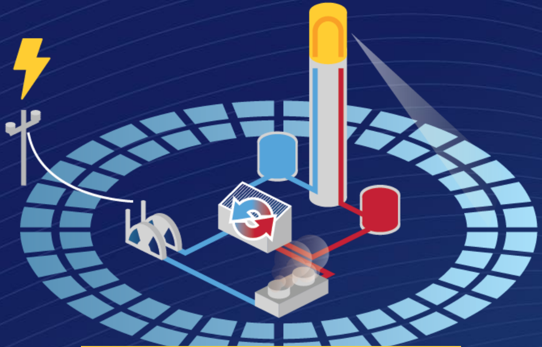
- Category A: High temperature receivers for CSP applications
- Category B: Low temperature CST receivers for IPH applications
- Category C: High temperature CST receivers and reactors for IPH

<u>Feedback Submission Deadline 2/20/24 5:00 PM EST</u>

Apply for funding through the

SMALL INNOVATIVE PROJECTS IN SOLAR (SIPS) PROGRAM

Think outside the box. Nearly any solar energy technology idea is eligible. SIPS aims to improve:



Concentrating Solar-Thermal Power

- Thermal energy storage
- Solar-thermal industrial processes
- Solar-thermal fuels
- Solar collectors (e.g. heliostats)
- Turbomachinery

Funding up to $400,000

Photovoltaics

- Power conversion efficiency
- Field performance
- Service lifetime
- Manufacturability
- Reuse and recycling

Funding up to $250,000

Produce significant results in 12-18 months

Quickly validate novel concepts

Lay the foundation for later-stage research and development

Learn more:
energy.gov/eere/solar/small-innovative-projects-solar-sips-program

SETO Newsletter – Stay in Touch

- The SETO newsletter highlights the key activities, events, funding opportunities, and publications that the solar program has funded.

SIGN UP NOW:

energy.gov/solar-newsletter

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