

U.S. Department of Energy

HelioCon

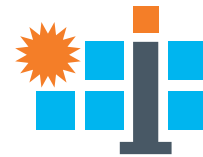
Heliostat Consortium for
Concentrating Solar-Thermal Power



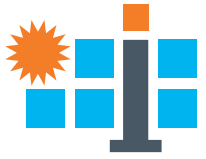
HelioCon: An International Heliostat Consortium to Advance Concentrating Solar Thermal Technologies

Margaret Gordon, PhD, Sandia National Laboratories

conceptual design • components • integration • mass production • heliostat field



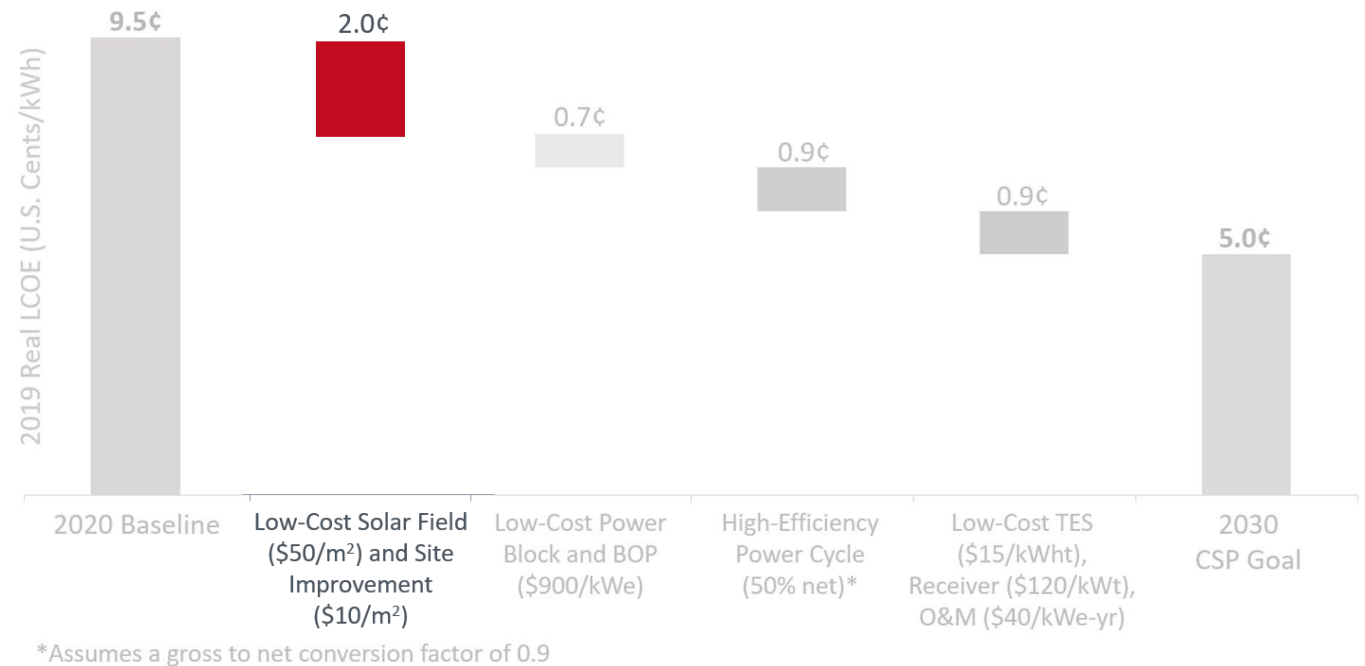
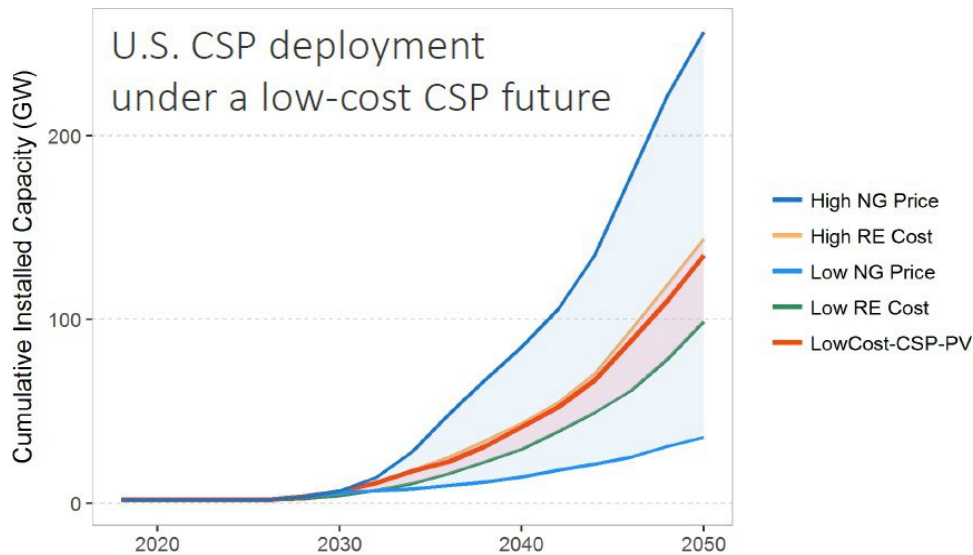
Sustainable Energy Needs



CSP Cost Opportunities

Predicting CSP electricity *only* in 2050 US grid:

- 35 – 200 GWe (3.5% - 20% of the total national electricity generation)



HelioStat Consortium (HelioCon) funded by DOE-SETO

5 year, \$25M + cost share begun in FY22

- To advance U.S. heliostat technologies, capabilities and national workforce
- 30% of funds allocated to annual Requests For Proposals (RFPs) for engagement of U.S. industries and other stake holders

Leadership team:

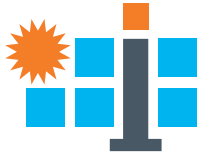
- Guangdong Zhu, Ph. D. (NREL), Mark Mehos, PhD. (NREL), Margaret Gordon, PhD. (Sandia), + NREL admin support
- Non-voting members: ASTRI Australian Solar Thermal Research Institute

Board of Advisors: Utility, developers, plant owners, component suppliers, EPCs, Academia, standards and international advisors

Members: Consortium funded project performers and cost-share providers.

Non-consortium stake-holders: Subject-matter experts; U.S. and international institutions.

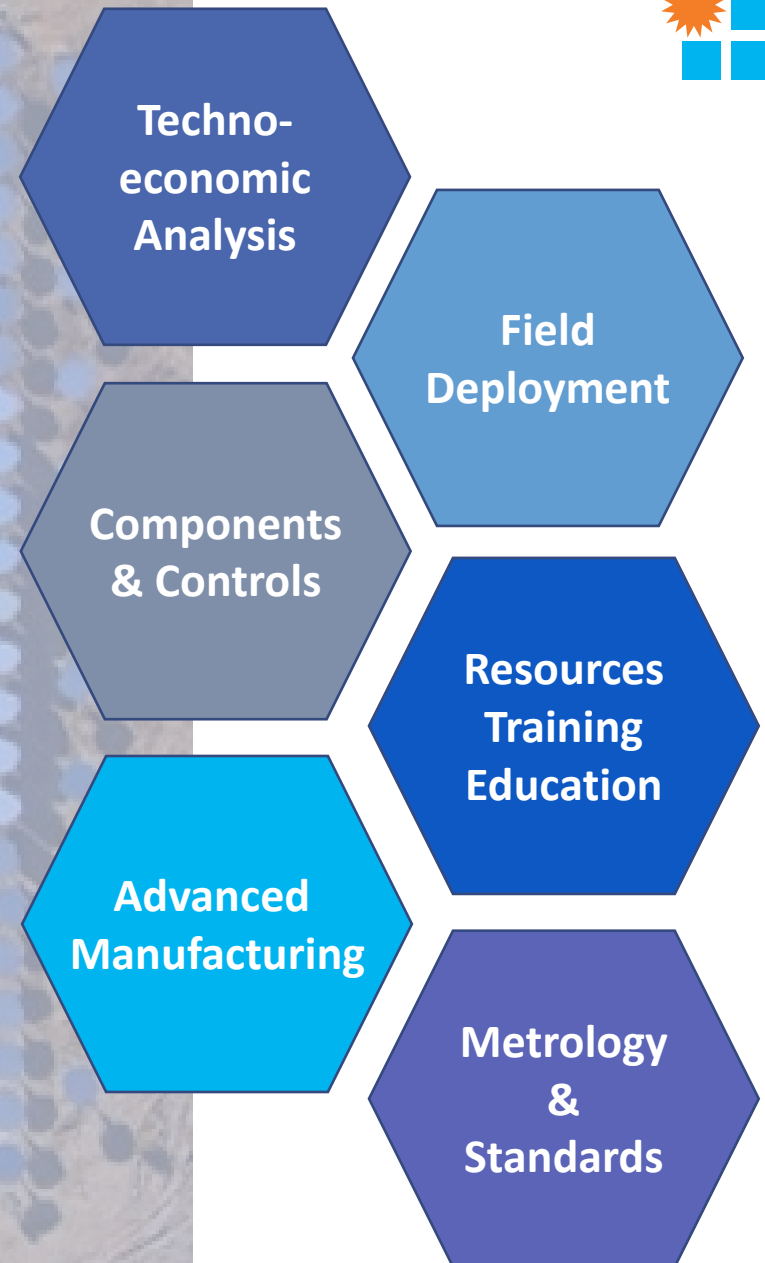


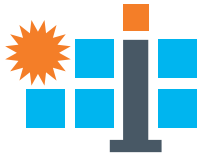


HelioCon Objectives

By the end of 2026, the Consortium will:

- **Form U.S. centers of excellence for heliostat technologies**
- **Develop strategic core testing and modeling capabilities and infrastructure at national labs (NREL and Sandia)**
- **Promote workforce development by integrating academia, industry and all stakeholders**





Plan → Support → Innovate → Validate



7 New project
Industry & Academia
Awardees



Support existing plants and stakeholders

- Outdoor field assessments – UFACET & NIO tests at Crescent Dunes, scheduling NIO test at Cerro Dominador)
- Round-Robin tests of metrology systems
- International collaborations



Improved tools and access to National Laboratory resources

- SAMS
- C&C Testbed
- OpenCSP
- Flatirons Campus
- NSTTF Heliostat Field + tower

Roadmap to Advance Heliostat Technologies for Concentrating Solar-Thermal Power

Guangdong Zhu,¹ Chad Augustine,¹ Rebecca Mitchell,¹ Matthew Muller,¹ Parthiv Kurup,¹ Alexander Zolan,¹ Shashank Yellapantula,¹ Randy Brost,² Kenneth Armijo,² Jeremy Sment,² Rebecca Schaller,² Margaret Gordon,² Mike Collins,^{3a} Joe Coventry,^{3b} John Pye,^{3b} Michael Cholette,^{3c} Giovanni Picotti,^{3c} Maziar Arjomandi,^{3d} Matthew Emes,^{3d} Daniel Potter,^{3d} and Michael Rae^{3d}

1 National Renewable Energy Laboratory
2 Sandia National Laboratories
3 Australia Solar Thermal Research Institute (ASTRI)
3a The Commonwealth Scientific and Industrial Research Organization
3b Australian National University
3c Queensland University of Technology
3d University of Adelaide

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
Technical Report
NREL/TP-5700-63041

This report is available at no cost
Laboratory (NREL) at www.nrel.gov

Contract No. DE-AC36-08G0283

HelioCon.org



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HelioCon
 Heliostat Consortium for
 Concentrating Solar-Thermal Power



HelioStat Technology Advancement
 REQUEST FOR PROPOSALS (RFP)
 RFP RFX-2022-10161

Submit proposals adhering to the template with page limits to HelioConRFP@nrel.gov by: 4:00 pm MT, Tuesday, November 8, 2022. Additional information about the HelioStat Consortium can be found at: <https://www.heliocon.org>

RFP Issue Date:	09/20/2022
RFP Webinar	10/10/2022 4:00 p.m. MDT
Submission Deadline for Full Proposal:	All Topic Areas: 11/08/2022 4:00 p.m. MT
Expected Date for Selection Notifications:	December 2022
Expected Time Frame for Award Negotiations:	January 2023 – February 2023

READ THIS DOCUMENT CAREFULLY

This solicitation is being conducted under the procedures for competitive subcontracts established by the National Renewable Energy Laboratory (NREL).

NREL will award a subcontract based on the following.

BEST VALUE SELECTION

All Statement of Work (SOW) requirements being met with the best combination of:

- * Technical factors (based on qualitative merit criteria), and
- * Evaluated price (or cost).

IMPORTANT DATES

Issue Date: September 20, 2022

Solicitation Webinar: October 10, 2022, 4:00 p.m. MDT

Deadline for Questions: October 14, 2022, 4:00 p.m. MDT

Response Due Date: November 8, 2022, 4:00 p.m. MT

Award Selection Anticipated: December 2022

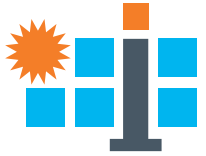
A webinar to address questions regarding the HelioCon RFP solicitation is scheduled for October 10 at 4:00 pm MDT. Interested parties can participate in the webinar by registering at:

[HelioCon RFP](#)

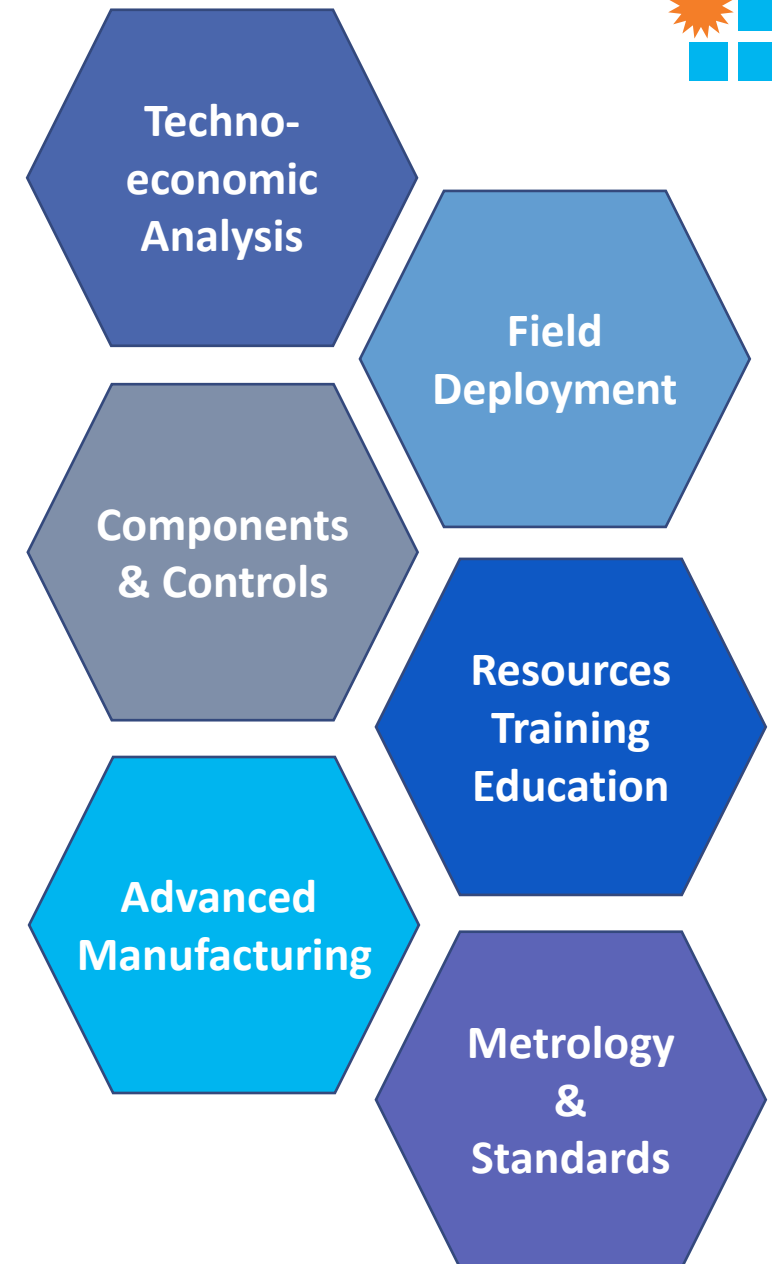
Round 1 RFP Awardees Announced in June 2023: Total \$3.5M, 7 Awardees

- Solar Dynamics - SunRing: Advanced Manufacturing and Field Deployment
- UNM HELIOCOMM: A Resilient Wireless Heliostats Communication System
- Northeastern U. - An Educational Program on Concentrating Solar Power and Heliostats for Power Generation and Industrial Processes
- Solar Dynamics - Demonstration of a Heliostat Solar Field Wireless Control System
- U. of AZ - Actively Focused Lightweight Heliostats
- Tietronix - Digital Twin and Industry 4.0 in Support of Heliostat Technology Advancement
- Sarcos - Robotic-Assisted Facet Installation (RA-FI)

HelioCon 2024 RFP



- Please watch for the Round 2 HelioCon RFP
 - Expect to award \$3M total
 - To fund 3-7 projects
 - Cost Share requirement
- Some NREL and Sandia Lab support possible
 - Access to facilities
 - Access to tools



Resources, Training & Education

Lead: Rebecca Mitchell

Major Gaps:

- Lack of publicly available resources
- Lack of awareness

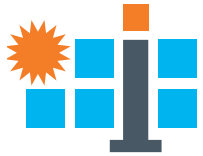
Rebecca Mitchell – Update on Resource, Training and Education **Tues. 12:00 This session**

Progress to date

- Hosting, recording and sharing monthly seminars with the public - 16 expert seminars, 2 training seminars
- Gathered available resources and knowledge into web database: 1)reference library; 2) Education and training resources; 3) Lists of heliostat component suppliers and developers, metrology tools, and software tools; 4)Existing power tower plant database

HelioCon Seminar Videos

Date	Title	Instructor	Video Link	Training Documents
April 10, 2023	CSP Tower Technology: 10+ Years of Innovation and 35+ Years of Mature Prior Innovation	Yoel Gilon	video	Slides, Flyer
March 1, 2023	Introduction of the 2022 CSP Blue Book of China	Zhifeng Wang	video	Slides, Flyer
February 1, 2023	Solar Field for CSP Tower Technology: Best Practices and Lessons Learned in Operational Commercial Projects	Raul Gonzalez Marcelo	video	Slides, Flyer
November 9, 2022	Mitigating Unconscious Bias in Work Teams	Anelisa Simons SNL	video	Slides, Flyer
October 19, 2022	Transferring Photovoltaic lessons learned to Concentrating Solar Power	Dr. Matthew Muller, NREL	video	Slides, Flyer
August 11, 2022	Advanced Manufacturing for Heliostats – What We Can Learn from Automotive Joining Technologies, Materials, and Automation	Wagon Willis, Gonzalez Group Dr. Randy Brost, Sandia	video	Slides, Flyer



conceptual design • components • integration • ma

	in Atmospheric Boundary Layer			
June 29, 2022	Soiling Losses for Concentrating Solar Power – Prediction, Assessment, and Mitigation	Dr. Michael Cholette, Queensland University of Technology	video	Slides, Flyer
June 8, 2022	Bottom-up Analyses for Two Heliostat Collectors and an Initial Heliostat Supply Chain	Parthiv Kurup, NREL	video	Slides, Flyer
May 18, 2022	Heliostat Components and Controls	Dr. Ken Armijo, Sandia	video	Slides, Flyer
April 13, 2022	Economies of Scale – Field Deployment Considerations to Accommodate Evolving Energy Markets	Dr. Jeremy Sment, Sandia	video	Slides, Flyer
March 30, 2022	What's Looking Up Down Under? Progress of Australian Solar Thermal	Mike Collins, CSIRO Energy	video	Slides, Flyer



Resources

The resources in this section include background on concentrating solar power (CSP), available scientific publications, videos, and additional information on heliostats.

- [Background on Concentrating Solar Power](#)
- [HelioCon Seminar and Educational Videos](#)
- [Zotero References](#)
- [HelioCon Publications](#)

August 1, 2022	HelioCon SolTrace Tutorial Session II: Implementing Advanced Geometries	Al Lewandowski	video	Files
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Components & Controls

Lead: Ken Armijo, Matt Muller



Major gaps:

- Lack of lower-cost design for heliostats
- Lack of closed-loop controls to achieve higher flux performance and auto alignment/calibration processes

Heliostat Structure

- Wind loading
- Material utilization
- Installation speed
- Fabrication (off-site/on-site/in-field)
- Rigidity/Accuracy/Sag



Mirror Facets

- Mirror quality / reflectivity
 - Glass thickness, type & backing
 - Soiling
- Facet design
 - Build variance, shape & orientation
 - Temp variance (Day & Year)



Azimuth Drive

Matt Muller – Evaluation of Composite Materials for Cost Reduction

Tues. 11:40 This session

Ken Armijo – NSTTF Closed Loop Controls Test Bed Development

Wed. 9:00 Session 5-12

and testing capabilities

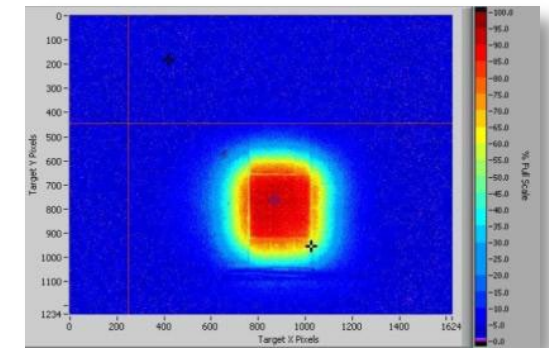
- Quality of calibration, frequency, and cost of calibration
- Wired Vs Wireless
- Security

- Backlash & Wear
- Accuracy
- Maintenance/Longevity
- Safety



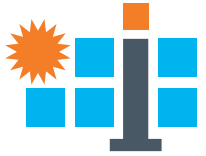
HelioCon Progress to date:

- Closed loop controls test bed is in development at the Sandia NSTTF
- Support for two RFP projects demonstrating wireless controls, and hardware/software upgrades to NSTTF to support testing.
- Software architectures utilized to determine optimal pointing of each heliostat, accounting for unique metrology considerations



Technoeconomic Analysis

Lead: Chad Augustine



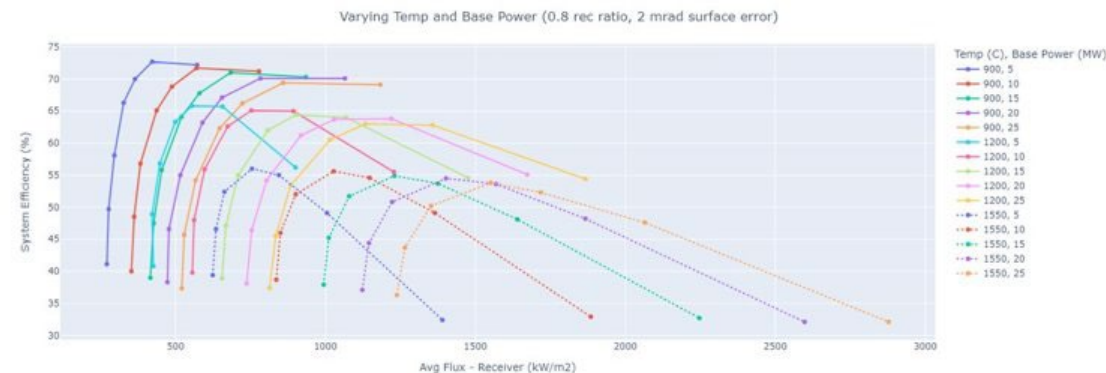
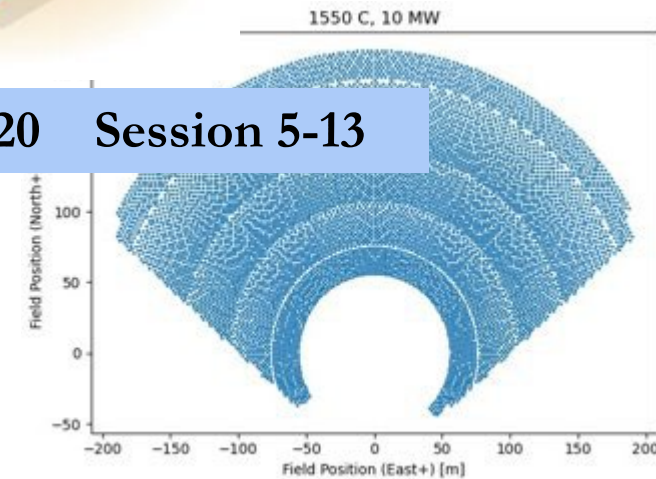
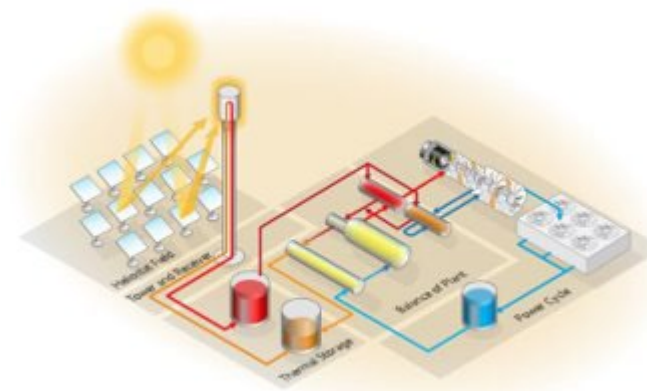
Major gaps

- Link between heliostat component research and its impact on TEA model inputs is poorly understood
- Lack of validated and widely accepted model for solar field O&M costs
- Insufficient knowledge of construction and commissioning costs, and the impact of delays on financing costs
- Lack of validated CSP models for IPH applications

Chad Augustine – Heliostat Field Optimization for IPH **Wed. 11:20** **Session 5-13**

Progress to date:

- Improving models required for TEA analysis
 - Developing cost correlations for tower and receiver for IPH, then optimizing base case field layouts
- Carrying out initial sensitivity analysis



Metrology & Standards



Major gaps

- Missing validated metrology technologies for opto-mechanical errors: Indoor, outdoor, post-installation
- Missing
 - He
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 - Sit

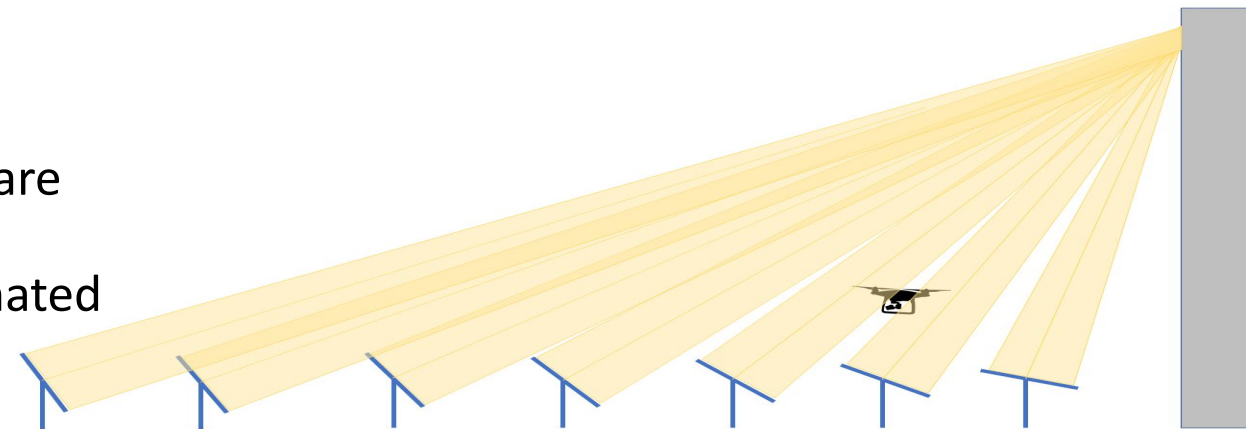


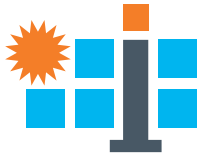
G.D. Zhu – Status Update on Metrology and Standards	Tues. 11:20	This session
Randy Brost – Extending Deflectometry Metrology	Wed. 9:40	Session 5-12
Randy Brost – High Speed Assessment of Heliostat Fields	Wed. 11:40	Session 5-13
Devon Kesseli – Indoor ReTNA Metrology System	Wed. 12:00	Session 5-13
Devon Kesseli – Characterizing Heliostats with NIO	Wed. 10:00	Session 5-12



Progress to date:

- SOFAST and ReTNA are being developed at labs, including ground truth verification
- NIO, UFACET and advanced outdoor deflectometry are being developed at labs
- Round robin for activities in-situ tools being coordinated with international society
- BCS systems are being improved and standardized
- Outdoor ground truth methods





Field Deployment

Lead: Jeremy Sment/Alex Zolan

Major gaps

- Heliostron investment **Alex Zolan – A Performance Forecasting Framework**
- Heliostron investment **Jeremy Sment – Status Quo on Field Deployment**
- Heliostat field integration with industrial thermal processes lacks precedent
- The site-specificity of O&M and field preparation/installation procedures limits the opportunity for incremental improvements that span multiple sites

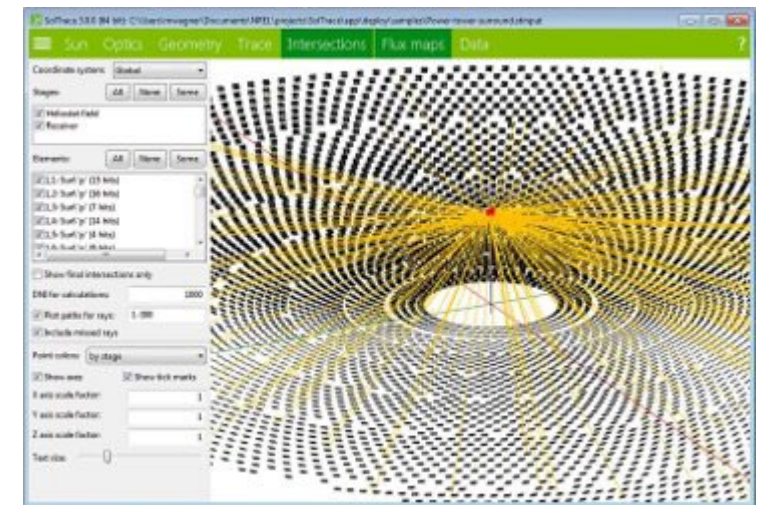
Progress to date:

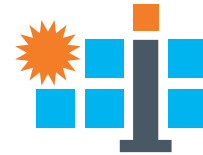
- We are developing a High Fidelity Performance forecasting methodology that characterizes key points of uncertainty to obtain confidence intervals on out-year performance (after learning has taken place).
- Stakeholder interviews are ongoing to obtain field deployment cost estimates.

System Advisor Model

The System Advisor Model (SAM) is a free user-friendly platform that calculates a renewable energy system's (sub-)hourly energy output and calculates detailed

Wed. 9:20 Session 5-12
Wed. 11:00 Session 5-13





Adv. Manufacturing

Lead: Randy Brost/Parthiv Kurup

Major gaps

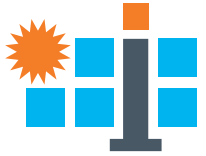
- Innovative heliostat mirror facet/array designs needed
- Insufficient facet/array fabrication process knowledge
- Heliostats not designed for high-productivity manufacturing
- Lack of heliostat developers' experience designing high-productivity manufacturing lines

Progress to date:

- RFP work by two awardees will advance concepts in this area. (U of Az – variable focused heliostat, and Solar Dynamics Sunring.)



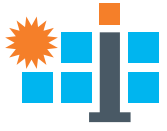
SunRing Heliostat, Solar Dynamics



Summary

- HelioCon has undertaken and funded significant efforts
 - Metrology and Standards Tools for indoor and outdoor, Components and Controls Testbed, Composite materials study, TEA Tools, Field performance analysis tools, Outreach and Education in RTE
- HelioCon has awarded \$3.5 M to industrial stakeholders and academic partners
- Created Heliocon.org, the HelioCon Seminar Series, and HelioCon database with resources





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HelioCon
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2023 HelioCon Workshop: Summary Session

Date: **Wednesday, July 12, 2023**
 Time: **1:00–5:15 p.m.**
 Location: **The Madison Hotel, Washington D.C.**
 Room: **Potomac A**



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

NREL
 Transforming ENERGY

Sandia
 National
 Laboratories

ASTRI
 Australian Solar Thermal
 Research Institute

CSIRO
 Australia's National
 Science Agency

**Australian
 National
 University**

**THE UNIVERSITY
 of ADELAIDE**

QUT
 Queensland University
 of Technology

SolarDynamics

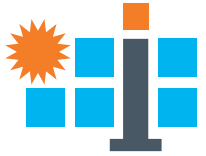
NM
 THE UNIVERSITY OF
 NEW MEXICO

**THE UNIVERSITY
 OF ARIZONA**

N Northeastern
 University

SARCOS TIIETRONIX

Heliostat Prize – Newly Announced Competition



<https://www.herox.com/heliostat>

\$3 million prize competition

- 3 Consecutive Contests
- Submissions due Aug. 31st, 2023

1. CONCEPT CONTEST: Creditable concept

✓ 3 months, 9 winners, \$100k each

2. DESIGN CONTEST: Initial design

✓ 4 months, 6 winners, \$180k each

3. ASSESS CONTEST: Prototype & testing

✓ 6 months, 3 winners, \$300k each

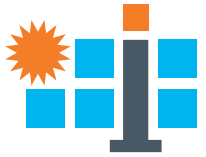
Goal:

- Structure
- Mirror facet
- Wireless control



Eligibility:

- Individuals – US citizen or permanent resident
- Group of Individuals – Online account holder of team captain must be a US citizen or permanent resident
- Private Entities - Be incorporated in and maintain a primary place of business in the US
- Academic Institutions – Based in the US



Metrology and Standards

Lead: Guangdong Zhu, NREL Guangdong.Zhu@nrel.gov
Co-Lead: Randy Brost, SNL rcbrost@sandia.gov

Soiling

Lead: Michael Cholette, ASTRI michael.cholette@qut.edu.au

Components and Controls

Lead: Ken Armijo, kmarmijo@sandia.gov
Co-Lead: Matthew Muller Matthew.Muller@nrel.gov

Advanced Manufacturing

Lead: Randy Brost, SNL rcbrost@sandia.gov
Co-lead: Parthiv Kurup, NREL Parthiv.Kurup@nrel.gov

Field Deployment

Lead: Jeremy Sment, jsment@sandia.gov
Co-Lead: Alex Zolan Alexander.Zolan@nrel.gov

Wind load

Lead: Matthew Emes, ASTRI matthew.emes@adelaide.edu.au

Techno-economic Analysis

Lead: Chad Augustine Chad.Augustine@nrel.gov
Co-Lead: Ken Armijo kmarmijo@sandia.gov

Resources, Training, and Education

Lead: Rebecca Mitchell Rebecca.Mitchell@nrel.gov
Co-Lead: Jeremy Sment jsment@sandia.gov

Questions? Thank you!

www.nrel.gov

csp.sandia.gov

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