



# ASME 2022 ES

16th International Conference on Energy Sustainability  
Co-Located with the 2022 Summer Heat Transfer Conference

CONFERENCE  
July 11-13, 2022

Philadelphia, Pennsylvania

# Program

[event.asme.org/ES](http://event.asme.org/ES)

The American Society of Mechanical Engineers®  
ASME®

  
**ASME**  
SETTING THE STANDARD

# Welcome

## FROM THE CONFERENCE CHAIRS

Dear Colleagues,

On behalf of the ASME's Advanced Energy System Division and Solar Energy Division, we cordially welcome you to the ASME 2022 Energy Sustainability Conference in Philadelphia!

Our conference theme "For a Sustainable Planet" serves as a reminder that the research presented here provides a technological basis upon which humanity might flourish long into the future. Renewable energy generation and energy efficiency are central to sustainability and to our ability to mitigate the worst impacts of climate change. This conference hosts researchers whose work addresses the most challenging and novel issues facing decarbonization of our buildings and energy supply and offers a glimpse into the exciting engineering solutions that are now coming into focus.

We mark a measured return to normalcy with the first in-person Energy Sustainability event since 2019, and we are hopeful that this venue will reunite our professional communities and rekindle the conversations and collaborations that are so important to advancing sustainable technologies. The Energy Sustainability Conference is co-located with the Summer Heat Transfer Conference to provide a unique opportunity for the attendees to expand their network and combine theory with application. We are proud to announce that we have a full schedule, including expert technical presentations, keynote and plenary speakers, and networking events. We are equally excited at the prospect of sharing a cup of coffee with an old colleague or getting to know a new one at one of the hosted lunches.

The committee offers a special "thank you" to our volunteer session chairs, reviewers, track organizers, and Executive Advisory Committee who have spent countless hours putting together a high-quality technical program. We would also like to thank ASME staff members for their support of the program, and we especially express our gratitude to our authors and presenters for sharing their latest research results with us.

We sincerely hope you enjoy the conference!

2022 Energy Sustainability Conference Organizing Committee

**Mike Wagner, Ph.D.**, Conference General Chair, AESD, University of Wisconsin-Madison

**Justin Lapp, Ph.D.**, Conference General Chair, SED, University of Maine

**Hamidreza Najafi, Ph.D.**, Technical Program Chair, AESD, Florida Institute of Technology

**Julia Nicodemus, Ph.D.**, Technical Program Chair, SED, Lafayette College

**Ben Xu, Ph.D.**, Technical Program Co-Chair, AESD, Mississippi State University

**Luke J. Venstrom, Ph.D.**, Technical Program Co-Chair, SED, Valparaiso University





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# Conference Information



## REGISTRATION INFORMATION

**Liberty Foyer, Ballroom Level**

### Registration Hours:

Sunday, July 10, 3:00PM–5:00PMPM

Monday, July 11, 7:00AM–5:30PM

Tuesday, July 12, 7:00AM–5:30PM

Wednesday, July 13, 7:00AM–12:30PM

## EXHIBIT INFORMATION

**Liberty Foyer, Ballroom Level**

### Hours

Monday, July 11, 10:00AM–04:00PM

Tuesday, July 12, 10:00AM–04:00PM

## AUDIOVISUAL EQUIPMENT IN SESSION ROOMS

All technical sessions are equipped with one LCD projector and one screen. Laptops will NOT be provided in the sessions. Presenters **MUST** bring their own or make arrangements in advance with the session chairs to share theirs. Please bring your presentation on a thumb drive 15 minutes prior to the session start time. A speaker ready room is available starting on Monday from 7:00AM–5:00PM and Wednesday until 12:00PM in the Franklin Room located on the Mezzanine Level.

## BADGE REQUIRED FOR ADMISSION

All conference attendees must wear the official ASME 2022 ES badge at all times in order to gain admission to technical sessions, exhibits, and other conference events. Without a badge, you will NOT be allowed to attend any conference activities.

## CONFERENCE AWARDS LUNCHEON

The Awards Luncheon will take place during the conference to recognize and celebrate a select group of individuals for their contributions and achievements in sustainable energy engineering and the ASME 2022 ES Conference. All conference attendees are invited to attend.

ES Awards Luncheon is on **Tuesday, July 12, 12:15PM–1:45PM** in the **Horizons Ballroom, on the Rooftop Level.**

## CONFERENCE LUNCHESES

Conference lunches will be held from 12:15PM to 1:45PM on Monday in Liberty B located on the Ballroom Level and Tuesday Awards Lunch in the Horizons Ballroom on the Rooftop Level. On Wednesday, lunch will be on your own. Please join your fellow attendees for a good meal and a great networking opportunity.

## CONFERENCE APP

**SHTC/ES 2022** is utilizing a mobile event app in place of a printed program to enhance the conference experience for all attendees.

You will be able to:

- Connect with Attendees
- View Speaker Profiles
- Access Session Information
- Watch On-Demand Content
- Download Final Papers
- And More!

\*All features may not be available at all events.

## CONFERENCE PROCEEDINGS

Each attendee will receive an email with a unique code to access digital copies of all the papers accepted for presentation at the conference. The official conference archival proceedings will be published after the conference and will not include accepted papers that were not presented at the conference. The official conference proceedings are registered with the Library of Congress and are submitted for abstracting and indexing. The proceedings are published on the ASME Digital Library. You will be provided with an individual link to the online papers via email. In the event you do not receive the email, send a request to [conferencepubs@asme.org](mailto:conferencepubs@asme.org)

## CONFERENCE REFRESHMENT BREAKS

Morning and afternoon breaks will be provided in the Liberty Foyer, Ballroom Level. Come and meet our exhibitors and join your fellow attendees for a few minutes of networking and discussion. The schedule is as follows:

**Monday–Tuesday, July 11–12**

**10:10AM–10:30AM and 3:40PM–4:00PM**

**Wednesday, July 13**

**10:10AM–10:30AM**

## TECHNICAL TOUR\*

**Wednesday, July 13**

8:00AM–12:00PM

\$35.00 for Members and Non-Members

**Tickets Required – Maximum of 30 participants**

<https://www.boeing.com/company/key-orgs/boeing-testing-services/wind-tunnels-and-propulsion.page#/speed>

\*U.S. Citizens or Green Card Holders only

Proof of Citizenship/Permanent Residence will be required upon arrival at Boeing.

Closed-Toed Shoes Required.

Safety Glasses will be supplied, but if you have your own, please bring them with you.

**Please meet at the main lobby by 17th street entrance sign. The buses will load on 17th between Race and Vine.**

## BOEING TECHNOLOGIES

The low-speed Boeing Vertical/Short Takeoff and Landing Wind Tunnel (BVWT), located in Philadelphia, has a large, versatile test section that is useful for testing fixed- and rotary-wing aircraft and non-aeronautical vehicles and structures. BVWT is a closed-circuit single-return tunnel and has a 20-by-20-foot, variable-configuration test section. The tunnel is capable of speeds of hover to 0.3 Mach, with a dynamic pressure range of 0 to 160 pounds per square foot.

It includes a fully automated test-model positioning system and airspeed controller, state-of-the-art data collection and instrumentation, and stainless steel honeycomb to improve flow quality. Touch-screen function control panels can display 30 monitored parameters. With the data updated every half second, these monitors provide for near-real-time display of multiple parameters.

The wind tunnel staff is experienced in all forms of force, pressure, flight control, vibratory, and dynamic testing of powered and unpowered fixed- and rotary-wing aircraft and other test articles in and out of ground effect.

## OPENING RECEPTION

**Sunday, July 10**

**6:30PM–8:00PM**

**Liberty B, Ballroom Level**

## EMERGENCY INFORMATION

If you are experiencing a health emergency, please dial 911. If you are able or someone else is able, please dial zero and inform the operator so that the hotel can be on the alert for the emergency response team. The hotel also has 24-hour security and officers trained in first aid, CPR, & AED service.

## INTERNET ACCESS

Complimentary basic internet is provided in sleeping rooms if you are staying at the Sheraton and in the hotel's public space. Internet in the meeting space will be limited to basic browsing.

## MEMBERSHIP TO ASME (4 MONTHS FREE)

Registrants who paid the non-member conference registration fees will receive a four-month complimentary ASME Membership. ASME will automatically activate this complimentary membership for qualified attendees. Please allow approximately four weeks after the conclusion of the conference for your membership to become active. Visit [www.asme.org/membership](http://www.asme.org/membership) for more information about the benefits of ASME Membership.

## PRESENTER ATTENDANCE POLICY

According to ASME's Presenter Attendance Policy, if a paper is not presented at the conference, the paper will not be published in the official Archival Proceedings, which are registered with the Library of Congress and are abstracted and indexed. The paper also will not be published in the ASME Digital Collection and may not be cited as a published paper.



# Schedule at a Glance

TIME	EVENT	ROOM
<b>SUNDAY, JULY 10, 2022</b>		
12:00PM–05:00PM	Registration	Liberty Foyer
6:30PM–08:00PM	Opening Reception - SHTC/ES	Liberty B
<b>MONDAY, JULY 11, 2022</b>		
7:00AM–5:30PM	Registration	Liberty Foyer
7:00AM–5:00PM	Speaker Ready Room	Franklin
9:00 AM–10:10AM	Keynote “Competing Realities in the Energy Transition,” Mark Alan Hughes, Ph.D.	Philadelphia Ballroom North & South
10:00AM–04:00PM	Boeing Exhibit	Liberty Foyer
10:10AM–10:30AM	AM Coffee Break- SHTC/ES	Liberty Foyer
10:30AM–12:10PM	06-01 Solar Thermochemical Hydrogen	India A
10:30AM–12:10PM	01-01 Nexus: Energy, Water and Climate I	Salon 3
10:30AM–12:10PM	02-01 Sustainable Buildings and Cities I	Salon 4
10:30AM–12:10PM	05-01 High Temperate Metrology	Salon 5
12:15PM–01:45PM	Boxed Lunch - SHTC &ES	Liberty B
2:00PM–3:40PM	03-01 Low Temperature Thermal Energy Storage	Salon 3
2:00PM–3:40PM	02-02 Sustainable Buildings and Cities II	Salon 4
2:00PM–3:40PM	05-02 Solar Receivers I	Salon 5
3:40PM–4:00PM	PM Coffee Break	Liberty Foyer
4:00PM–5:40PM	10-01 Alternative Energy Conversion Technologies	Salon 3
4:00PM–5:40PM	09-01 Solar Desalination and Industrial Process Heat	Salon 4
4:00PM–5:40PM	05-03 CSP Heat Exchangers I	Salon 5
<b>TUESDAY, JULY 12, 2022</b>		
7:00AM–5:30PM	Registration	Liberty Foyer
7:00AM–5:00PM	Speaker Ready Room	Franklin
9:00AM–10:10AM	Plenary Session “Concentrated solar thermal: optics, heat transfer, chemistry,” Wojciech Lipinski, Ph.D.	Philadelphia Ballroom North & South
10:00AM–04:00PM	Boeing Exhibit	Liberty Foyer
10:10AM–10:30AM	AM Coffee Break- SHTC/ES	Liberty Foyer
10:30AM–12:10PM	02-03 Sustainable Heating and Cooling	Salon 3
10:30AM–12:10PM	03-02 High Temperature Thermal Energy Storage	Salon 4
10:30AM–12:10PM	05-04 CSP Heat Exchangers II	Salon 5
12:15PM–01:45PM	Awards Luncheon - ES	Horizons
2:00PM–3:40PM	10-02 Alternative Energy Conversion Technologies II	Salon 3

# Schedule at a Glance

TIME	EVENT	ROOM
2:00PM–3:40PM	06-02 Solar Thermochemical Fuels	Salon 4
2:00PM–3:40PM	05-05 Solar Collectors	Salon 5
3:40PM–4:00PM	PM Coffee Break	Liberty Foyer
4:00PM–5:40PM	01-02 Nexus: Energy, Water and Climate II	Salon 3
4:00PM–5:40PM	06-03 Solar Reaction Engineering	Salon 4
4:00PM–5:40PM	05-06 CSP Systems	Salon 5
4:00PM–5:40PM	14-01 Ocean, Hydro and Wind Power Technologies	India A
6:45PM–7:45PM	Solar Energy Division Executive Committee Meeting	Salon 3
08:00PM–09:00PM	Solar Energy Division/Advanced Energy Systems Division Meeting	Salon 3
<b>WEDNESDAY, JULY 13, 2022</b>		
7:00AM–12:30PM	Registration	Liberty Foyer
7:00AM–12:00PM	Speaker Ready Room	Franklin
8:00AM–12:00PM	Boeing Tour	Bus will board at 8:00AM Sharp!
8:45AM–10:10AM	Panel Session "HelioCon: A Consortium Focused on Accelerating Heliostat Technology Improvement," Guangdong Zhu, Ph.D.; Kenneth Armijo, Ph.D.; Avi Shultz, Ph.D.; Mike Wagner, Ph.D.; Kyle Kattke, P.E.	Philadelphia Ballroom North & South
10:10AM–10:30AM	AM Coffee Break	Liberty Foyer
10:30AM–12:10PM	Panel on Research Funding Opportunities: NSF and DOE	Liberty A
10:30AM–12:10PM	02-04 Sustainable Heating and Cooling II	Salon 3
10:30AM–12:10PM	03-03 Compressed Air & Thermochemical Energy Storage	Salon 4
10:30AM–12:10PM	05-07 Solar Receivers II	Salon 5
12:15PM	<b>END OF CONFERENCES/LUNCH ON OWN</b>	

# Keynote/Plenary/Panel Sessions and Committee Meetings

COMMITTEE	DAY	DATE	START TIME	END TIME	ROOM
Solar Energy Division Executive Committee Meeting (Open)	Tuesday	July 12	6:45PM	7:45PM	Salon 3
Solar Energy Division/Advanced Energy Systems Division Meeting (Closed)	Tuesday	July 12	8:00PM	9:00PM	Salon 3

KEYNOTE LECTURES	DAY	DATE	START TIME	END TIME	ROOM
Keynote "Competing Realities in the Energy Transition," Mark Alan Hughes, Ph.D.	Monday	July 11	9:00AM	10:10AM	Philadelphia Ballroom North & South
Plenary Session "Concentrated solar thermal: optics, heat transfer, chemistry," Wojciech Lipinski, Ph.D.	Tuesday	July 12	9:00AM	10:10AM	Philadelphia Ballroom North & South
Panel Session "HelioCon: A Consortium Focused on Accelerating Heliostat Technology Improvement," Guangdong Zhu, Ph.D.; Kenneth Armijo, Ph.D.; Avi Shultz, Ph.D.; Mike Wagner, Ph.D.; Kyle Kattke, P.E.	Wednesday	July 13	8:45AM	10:10AM	Philadelphia Ballroom



## KEYNOTE LECTURE

MONDAY, JULY 11 • 9:00AM–10:10AM

PHILADELPHIA BALLROOM, MEZZANINE LEVEL



Mark Alan Hughes, Ph.D.

### Competing Realities in the Energy Transition

**ABSTRACT:** There are many competing appeals to reality made in debates over the energy transition, such as “the energy system can’t change overnight” and “the costs of climate change driven by the existing energy system will crush global economies”. These appeals don’t compete on facts because most of them are either defensible or irrefutable. Rather they compete for the right to organize the agenda, to determine the binding constraints and next steps of collective action. They also compete over the direction of research in engineering and applied science. This talk explores some notable collisions between major competing realities. What if we stipulate the claims of competing realities and focus instead on the informed choices that result? Perhaps it’s time to stop debating who’s right, and instead decide who wins.

**BIOGRAPHY:** Mark Alan Hughes is founding faculty director of the Kleinman Center for Energy Policy. He is a professor of practice in regional planning and energy policy appointed in the Department of Landscape Architecture and Regional Planning at the University of Pennsylvania Stuart Weitzman School of Design. He is also a faculty fellow of the Penn Institute for Urban Research and a research fellow of the Wharton Risk Center. Hughes is the author and performer of the 2021 audiobook *Livable Cities*.

Hughes joined the standing faculty of Princeton University’s Woodrow Wilson School in 1986 at the age of 25 and joined the associated faculty of the University of Pennsylvania in 1999. He has published in the leading journals of economic geography, urban economics, political science, policy analysis, and won the National Planning Award for his research in city and regional planning in 1992.

He was chief policy adviser to Mayor Michael A. Nutter and the founding director of sustainability for the City of Philadelphia, where he led the creation of the Greenworks Plan in 2009. He has designed and fielded national policy research projects in a variety of areas including the Bridges to Work program in transportation, the Transitional Work Corporation in job training and placement, the Campaign for Working Families in EITC participation, and the Energy Efficient Buildings Hub in regional economic development. This work has been funded by H.U.D., H.H.S., D.O.E., Ford, Rockefeller, Pew, Casey, WmPenn, and others.

He was the inaugural nonresident senior fellow at the Brookings Institution’s Center for Urban and Metropolitan Policy founded by Bruce Katz; the first vice president of policy development at the national intermediary Public/Private Ventures established by the Ford Foundation in Philadelphia; and a weekly opinion columnist for five years at the

Philadelphia Daily News, where he was named one of the best columnists in the U.S. by *The Week* magazine in 2004.

Hughes earned a Ph.D. in regional science from the University of Pennsylvania in 1986, and a B.A. in religion and art history from Swarthmore College in 1981.

## PLENARY SESSION

TUESDAY, JULY 12 • 9:00AM–10:10AM

PHILADELPHIA BALLROOM, MEZZANINE LEVEL

### SOLAR ENERGY DIVISION 2020 YELLOTT AWARD WINNER LECTURE



Wojciech Lipiński, Ph.D.  
Independent Researcher

### Concentrated Solar Thermal: Optics, Heat Transfer, Chemistry

**ABSTRACT:** High-flux solar irradiation obtained with optical concentrators is a viable source of clean process heat for high-temperature physical and chemical processing. Traditionally, the progress in concentrating solar thermal technologies has been driven by advancements in concentrated solar power, in particular in the context of large-scale dispatchable power generation. Solar thermochemistry is concerned with direct thermochemical production of chemical fuels and materials processing, without intermediate electricity generation. This presentation gives an overview of recent developments in high-temperature solar thermal and thermochemical processing, from basic research to applications, with focus on optical, thermodynamic, heat transfer, and chemical reaction studies.

**BIOGRAPHY:** Wojciech Lipiński obtained his Master of Science degree in environmental engineering from Warsaw University of Technology (2000), doctorate in mechanical and process engineering from ETH Zurich (2004), and habilitation in energy technology from ETH Zurich (2009). His research interests encompass transport phenomena and reaction engineering, with applications in energy and environmental technology. He has published over 190 articles in refereed journals and conference proceedings.

# Lectures, Keynote Speakers, and Panels

## PANEL SESSION

WEDNESDAY, JULY 13 • 8:45AM–10:10AM

PHILADELPHIA BALLROOM, MEZZANINE LEVEL

### HelioCon: A Consortium Focused on Accelerating Heliostat Technology Improvement

**ABSTRACT:** The HelioCon consortium emphasizes the significance of heliostats as a key component of concentrating solar power (CSP) technologies. CSP with low-cost thermal energy storage can be used either to produce dispatchable electricity or provide high-temperature heat to difficult-to-decarbonize industries, such as cement, steel, and chemical production. The consortium supports research, development, validation, commercialization, and deployment of low-cost and high-performance heliostats with optimized operations and maintenance for CSP and concentrating solar-thermal applications. Within HelioCon, NREL, Sandia National Laboratories, and the Australian Solar Thermal Research Institute work closely with the U.S. Department of Energy (DOE) and CSP developers, component suppliers, utilities, and international experts. Panelists provide insight into heliostat field developments, covering topics including components and controls, metrology, current research objectives, and educating the next generation of heliostat experts.



**Dr. Guangdong Zhu**

HelioCon Executive Director and Metrology & Standards Lead

**BIOGRAPHY:** Dr. Guangdong Zhu has been a senior researcher in the concentrating solar power (CSP) program and geothermal technology program at the National Renewable Energy Laboratory (NREL) since 2010. At NREL, he has been leading research efforts related to solar collector optical characterization, linear Fresnel technology, and renewable energy hybridization. He is the executive director of the newly formed 5-year heliostat consortium co-led by NREL and Sandia National Labs, partnering with ASTRI. He is the associate editor of the ASME Journal of Energy Resources Technology since 2019. He has served as technical/general program chair for ASME Energy Sustainability international conference in 2017–2020. He won NREL's President's award and Outstanding New Partnership Award in 2016. He has published over 40 peer-reviewed journal/conference papers and given numerous invited presentations at various research institutes. Dr. Zhu obtained his Ph.D. from the University of New Mexico in 2006.



**Dr. Kenneth Armijo**

HelioCon Components & Controls Lead

**BIOGRAPHY:** Dr. Kenneth Armijo is a systems engineering staff member who leads molten salt and molten alkali metals R&D at the National Solar Thermal Test Facility (NSTTF). His research interests are in alternative energy technologies and sustainability, as they pertain to scientific and technological innovation, business, and policy. Dr. Armijo holds a Ph.D. in Mechanical Engineering from the University of California, Berkeley with minors in Energy and Resources, and business credentials in Management of Technology from Berkeley's Haas School of Business. Presently, Dr. Armijo is the lead for the HelioCON Components and Controls Task, which is co-lead with Matt Mueller from NREL. His research in concentrating solar power (CSP) also consists of system design for high-temperature (>720°C) thermodynamic and commercial R&D systems, employing ternary chloride molten salts and alkali metals (sodium) as the heat transfer fluid. He is the test site Principle Investigator (PI) for multiple U.S. Dept. of Energy (DOE) projects in CSP that also includes pumped thermal energy systems. His research has also consisted of falling particles for centralized concentrating solar receivers and solar reactors for industrial process heat applications and climate change mitigation technologies. He also leads research activities pertaining to solar Stirling Engine applications as well as for solar reactor R&D and high-flux materials characterization. Dr. Armijo also serves as a lead Test Director for high-temperature materials research for Aerospace applications, such as Re-Entry and Hypersonic vehicles.



**Dr. Avi Shultz**

**BIOGRAPHY:** Dr. Avi Shultz is the program manager for concentrating solar-thermal power (CSP) for the U.S. Department of Energy's Solar Energy Technologies Office (SETO), which supports research, development, and demonstration of solar-thermal components and systems that can enable wide-spread deployment of low-cost CSP with thermal energy storage. Dr. Shultz has been with SETO since 2013, where he started as a science and technology policy fellow, supporting the CSP program on a wide variety of topics. He manages a program that supports research, development, and demonstration of solar thermal components and systems, for both electricity and industrial process heat, that can enable wide-spread deployment of low-cost CSP with thermal energy storage. Before joining SETO, Dr. Shultz was a post-doctoral fellow at the University of Amsterdam, after getting his Bachelor and Doctoral degrees in Chemistry, from Columbia University and Northwestern University, respectively.



Dr. Mike Wagner

**BIOGRAPHY:** Dr. Mike Wagner is an Assistant Professor of Mechanical Engineering at the University of Wisconsin-Madison, where he teaches and conducts research on optimal design and operations of renewable energy and energy storage technologies. He is principal investigator of the Energy Systems Operations Lab research group, a faculty member of the Solar Energy Lab, and a faculty affiliate of the Wisconsin Electric Machines and Power Electronics Consortium. His research includes thermal systems modeling, system design and operations optimization, and predictive performance analysis of energy generation and storage technologies. Prior to joining UW-Madison, he was a senior researcher and principal investigator at NREL where he was involved in development of optical and thermal modeling software, including SAM, SolarPILOT, and SolTrace. Dr. Wagner is a graduate of the University of Wisconsin-Madison (B.S., M.S.) and Colorado School of Mines (Ph.D.).



Kyle Kattke, P.E.

**BIOGRAPHY:** Kyle Kattke, P.E., is a project manager and senior engineer at Solar Dynamics LLC, a CSP technology and consulting company in the United States. He is the PI on the DOE-funded 'Drop-C' project which resulted in the novel SunRing heliostat. He managed the development of the heliostat's space frame support structure, novel azimuth drive system, integrated controller, and wireless solar field communication. Additionally, Kattke leads performance modeling efforts at Solar Dynamics where he has delivered system performance models to commercial parabolic trough plants. Prior to joining Solar Dynamics, he worked for Abengoa Solar USA on the development of an advanced, low cost heliostat which was the precursor to the SunRing. Kattke holds a bachelor's degree from the South Dakota School of Mines and Technology and a master's degree from the Colorado School of Mines both in mechanical engineering.

## RESEARCH FUNDING OPPORTUNITIES PANEL

WEDNESDAY, JULY 13 • 10:30AM–12:10PM

LIBERTY A, BALLROOM LEVEL

Program Directors from the National Science Foundation and the Department of Energy will discuss research programs and funding opportunities in areas of interest to participants in the Summer Heat Transfer Conference including Thermal Transport, Thermal Management, Solar Energy, Energy Efficiency, and several new funding initiatives.



Dr. Ying Sun

National Science Foundation

**BIOGRAPHY:** Dr. Sun is Program Director of the Thermal Transport Processes Program in the Directorate for Engineering at the National Science Foundation. The program supports fundamental research in thermodynamics, and heat and mass transfer, including thermal solutions to climate change and quantum-thermal interface. Dr. Sun is also Hess Family Endowed Chair Professor in the Department of Mechanical Engineering and Mechanics at Drexel University. Her research interests include multiphase flows and heat/mass transfer, complex fluids and interfacial phenomena, machine learning and data-driven methods, and multi-scale modeling with applications in energy systems and advanced manufacturing. Dr. Sun is an ASME Fellow and a recipient of the NSF CAREER Award, AFOSR Summer Faculty Fellowship, French CNRS Visiting Professorship, and Drexel College of Engineering Research Achievement Award. She serves as an Associate Editor for Journal of Electrochemical Energy Conversion and Storage and was an ELATE Leadership Fellow and a visiting professor at Princeton University, Ecole Polytechnique, and Tsinghua University.



Dr. Avi Shultz

U.S. Department of Energy's Solar Energy Technologies Office (SETO)

**BIOGRAPHY:** Dr. Shultz is the program manager for concentrating solar-thermal power (CSP) for the U.S. Department of Energy's Solar Energy Technologies Office (SETO), which supports research, development, and demonstration of solar-thermal components and systems that can enable wide-spread deployment of low-cost CSP with thermal energy storage. Dr. Shultz has been with SETO since 2013, where he started as a science and technology policy fellow, supporting the CSP program on a wide variety of topics. Before joining SETO, Dr. Shultz was a post-doctoral fellow at the University of Amsterdam, after getting his Bachelor and Doctoral degrees in Chemistry, from Columbia University and Northwestern University, respectively.

# 2022 Awards Recognitions

## OUTSTANDING PAPER AWARD

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**1. ES2022-81870, Probabilistic Modeling of Climate Change Impacts on Renewable Energy and Storage Requirements for NM's Energy Transition Act**

Clifford K. Ho, Erika L. Roesler, Tu Nguyen, and James Ellison

**2. ES2022-84345, Net-Zero Energy Home Design Using Photovoltaic-based Distributed Energy Generation and Multi-functional Flow Systems Integrated with Thermal Energy Storage**

Dongsu Kim, Kelly Tran, Jaeyoon Koh, and Heejin Cho

**3. ES2022-80943, Scalable and High-performance Core-shell Microparticle Embedded Polymer Coating for Thermal-controllable Passive Radiative Cooling**

Siru Chen, Aiqiang Pan, Kaixin Lin, Hau Him

## OUTSTANDING STUDENT PAPER AWARD

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**1. ES2022-84122, A Scalable Compact Additively-manufactured Molten-salt to Supercritical Carbon Dioxide Heat Exchanger for Solar Thermal Application**

Ines-Noelly Tano, Erfan Rasouli, Tracey Ziev, Junwon Seo, Nicholas Lamprinakos, Parth Vaishnav, Anthony Rollett, Ziheng Wu, Vinod Narayanan

**2. ES2022-81591, Optimization of Energy Storage Systems and Demand Side Management to Maximize Water Utility Savings: A Hawaii Case Study**

Yogesh Manoharan, Keith Olson, Alexander John Headley





## MONDAY, JULY 11, 2022

### 01-01 NEXUS: ENERGY, WATER AND CLIMATE I

10:30AM–12:10PM

SALON 3

Session Chair: **Shuang Cui** - *University of Texas at Dallas*

#### **Internet of Energy Applied to Water Hydrokinetic Smart-Grids: A Test Rig Example of Energy Applied to Water Hydrokinetic Smart-Grids: A Test Rig Example**

Technical Paper Publication: ES2022-85552

**Ahmed Gharib Yosry** - *University of Oviedo*, **Aitor Fernández Jiménez** - *University of Oviedo*, **Víctor Manuel Fernández Pacheco** - *University of Oviedo*, **Manuel Rico Secades** - *University of Oviedo*

#### **Sustainability Improvement of Membrane Separation Process for Post-Combustion CO<sub>2</sub> Capturing Using Multi-Objective Optimization**

Technical Paper Publication: ES2022-81636

**Javad Asadi** - *University of Oklahoma*, **Pejman Kazempoor** - *University of Oklahoma*

#### **Efficiency and Flexibility Improvement of Amine-Based Post Combustion CO<sub>2</sub> Capturing System (CCS) in Full and Partial Loads**

Technical Paper Publication: ES2022-81639

**Javad Asadi** - *University of Oklahoma*, **Lateef Jolaoso** - *University of Oklahoma*, **Pejman Kazempoor** - *University of Oklahoma*

#### **Probabilistic Modeling of Climate Change Impacts on Renewable Energy and Storage Requirements For NM's Energy Transition Act Modeling of Climate Change Impacts on Renewable Energy and Storage Requirements**

Technical Paper Publication: ES2022-81870

**Clifford Ho** - *Sandia National Laboratories*, **Erika Roesler** - *Sandia National Laboratories*, **Tu Nguyen** - *Sandia National Laboratories*, **James Ellison** - *Sandia National Laboratories*

### 05-01 HIGH TEMPERATURE METROLOGY

10:30AM–12:10PM

SALON 5

Session Chair: **Zachary Berquist** - *University of Michigan*

#### **Experimental Demonstration of High-Efficiency Refractory Aerogel-Integrated Linear Receiver for Concentrating Solar Power**

Technical Presentation Only: ES2022-84368

**Ali Davoodabadi** - *University of Michigan*, **Zachary Berquist** - *University of Michigan*, **Andrej Lenert** - *University of Michigan*

#### **Experimental Investigation of Effect of Micro-Cavity on the Effective Solar Absorbance of White Sand Curtain**

Technical Presentation Only: ES2022-85385

**Rageh Saeed** - *King Saud University*, **Shaker Alaqel** - *King Saud University*, **Nader S. Saleh** - *King Saud University*, **Eldwin Djajadiwinata** - *King Saud University*, **Abdulah Alswaiyd** - *King Saud University*, **Hany Al-Ansary** - *King Saud University*, **Abdelrahman El-Leathy** - *King Saud University*, **Syed Danish** - *King Saud University*, **Zeyad Al-Suhaibani** - *King Saud University*, **Ryan Yeung** - *Georgia Institute of Technology*, **Muhammad Sarfraz** - *Georgia Institute of Technology*, **Sheldon Jeter** - *Georgia Institute of Technology*

#### **A Non-Intrusive Particle Temperature Measurement Methodology Using Thermogram and Visible-Light Image Sets**

Technical Paper Publication: ES2022-81801

**Jesus Ortega** - *University of New Mexico*, **Guillermo Anaya** - *University of New Mexico*, **Clifford Ho** - *Sandia National Laboratories*, **Peter Vorobieff** - *University of New Mexico*, **Gowtham Mohan** - *University of New Mexico*

#### **Temperature-Dependent Radiative Property Measurements for Non-Contact Temperature Measurements in High Temperature Systems**

Technical Presentation Only: ES2022-91038

**Mike Mayer** - *University of Michigan*, **Rohini Bala Chandran** - *University of Michigan*



# Technical Sessions

## 06-01 SOLAR THERMOCHEMICAL HYDROGEN

10:30AM–12:10PM

INDIA A

Session Chair: **Brendan Bulfin** - *ETH Zurich*

### **Fully-Automated and Feedback Loop-Controlled Solar Fuel System for the Thermochemical Production of Syngas From H<sub>2</sub>O and CO<sub>2</sub> Applicable for Methanol or Fischer-Tropsch Synthesis**

Invited Speaker Presentation: ES2022-87873

**Remo Schächli** - *ETH Zurich*, **Vivien Hüsler** - *ETH Zurich*, **Aldo Steinfeld** - *ETH Zurich*

### **High-Fidelity Modeling and Optimization of the Reactor Train for Efficient and Scalable Solar Thermochemical Fuel Production**

Technical Presentation Only: ES2022-80332

**Aniket Patankar** - *Massachusetts Institute of Technology*, **Haodong Huang** - *Southern University of Science and Technology*, **Xiao-Yu Wu** - *University of Waterloo*, **Wonjae Choi** - *Ewha Womans University*, **Harry Tuller** - *Massachusetts Institute of Technology*, **Meng Lin** - *Southern University of Science and Technology*, **Ahmed Ghoniem** - *Massachusetts Institute of Technology*

### **Sustainable Solar Fuels: Water Use, Carbon Emissions, and Cost of Hydrogen and Syngas From Solar Thermochemical Fuel Production Cycles**

Technical Presentation Only: ES2022-82582

**Julia Nicodemus** - *Lafayette College*, **Paige Ferrell** - *Paige Ferrell*, **Ava Shore** - *Lafayette College*

### **3D-Printed Porous Ceria Structures for Solar Thermochemical Redox Splitting of CO<sub>2</sub>**

Technical Presentation Only: ES2022-86296

**Sebastian Sas Brunser** - *ETH Zurich*, **Hugo Braun** - *ETH Zurich*, **Fabio Luca Bargardi** - *ETH Zurich*, **Rafael Libanori** - *ETH Zurich*, **André R. Studart** - *ETH Zurich*, **Aldo Steinfeld** - *ETH Zurich*

## 02-01 SUSTAINABLE BUILDINGS AND CITIES I

10:30AM–12:10PM

SALON 4

Session Chair: **Iyad Hijazi** - *Marshall University*

### **Increasing Optical Efficiency of LSCS Through Asymmetric Light Transmission Interfaces**

Technical Presentation Only: ES2022-81863

**Vincent Oliveto** - *Rensselaer Polytechnic Institute*, **Bhakti Patel** - *Rensselaer Polytechnic Institute*, **Duncan Smith** - *Rensselaer Polytechnic Institute*, **Michael Hughes** - *Rensselaer Polytechnic Institute*, **Diana-Andra Borca-Tasciuc** - *Rensselaer Polytechnic Institute*

### **Multi-Parameter Optimization of Levelized Cost of Electricity of Luminescent Solar Concentrators**

Technical Presentation Only: ES2022-83231

**Duncan Smith** - *Rensselaer Polytechnic Institute*, **Alex Wu** - *Rensselaer Polytechnic Institute*, **Yifan Wang** - *Rensselaer Polytechnic Institute*, **Nathan Wassermann** - *Rensselaer Polytechnic Institute*, **Michael Hughes** - *Rensselaer Polytechnic Institute*, **Diana-Andra Borca-Tasciuc** - *Rensselaer Polytechnic Institute*

### **Ambient Temperature-Independent Building System**

Technical Presentation Only: ES2022-94158

**Sang Woo Karng** - *Korea Institute of Science and Technology*, **Hyun Ji Kim** - *Seoul National University*, **Myeong-Seon Chae** - *Paul Scherrer Institut*, **Youhwan Shin** - *Korea Institute of Science and Technology*, **Gwang Hoon Rhee** - *University of Seoul*

### **A Review of Passive Cooling Technology Performance Testing Methods**

Technical Paper Publication: ES2022-81877

**David Young** - *University of South Florida*, **Elias K. Stefanakos** - *University of South Florida*, **D. Yogi Goswami** - *University of South Florida*

## 02-02 SUSTAINABLE BUILDINGS AND CITIES II

2:00PM–3:40PM

SALON 4

Session Chair: **Darshan Pahinkar** - *Florida Institute of Technology*

### A PCM-Based Passive Building for Electric Load Reduction

Technical Presentation Only: ES2022-94150

**Hyun Ji Kim** - *Seoul National University*, **Myeong-Seon Chae** - *Paul Scherrer Institut*, **Youhwan Shin** - *Korea Institute of Science and Technology*, **Yong Tae Yoon** - *Seoul National University*, **Sarng Woo Karng** - *Korea Institute of Science and Technology*

### Optimization of Energy Storage Systems and Demand Side Management to Maximize Water Utility Savings: A Hawaii Case Study

Technical Paper Publication: ES2022-81591

**Yogesh Manoharan** - *The University of Memphis*, **Keith Olson** - *Natural Energy Laboratory of Hawaii Authority*, **Alexander Headley** - *The University of Memphis*

### Modeling and Analysis of a Zero-Energy Building Using Artificial Neural Network: A Case Study for Florida

Technical Paper Publication: ES2022-84366

**Mariana Migliori** - *Florida Institute of Technology*, **Hamidreza Najafi** - *Florida Institute of Technology*, **Troy Nguyen** - *Florida Institute of Technology*, **Aldo Fabregas** - *Florida Institute of Technology*

### Hybrid Model Approaches for Residential Building Energy Analysis: Integration of Occupants' Impact

Technical Presentation Only: ES2022-91073

**Yang-Seon Kim** - *Wichita State University*, **Amin Hosseini** - *Wichita State University*

### Pioneering the Use of Renewable Energy for Agriculture in Gabon, Africa

Technical Presentation Only: ES2022-91057

**Kibria Roman** - *State University of New York at Canton*, **Van Moussavou** - *State University of New York at Canton*, **Fardin Ishtiaq** - *Bangladesh University of Engineering and Technology*, **Hossain Azam** - *University of the District of Columbia*

## 03-01 LOW TEMPERATURE THERMAL ENERGY STORAGE

2:00PM–3:40PM

SALON 3

Session Chair: **Rohini Bala Chandran** - *University of Michigan*

### Subsurface Geothermal Energy Storage With Solar Thermal Hybridization for Seasonal Dispatching: A Future Potential and Perspective

Invited Speaker Presentation: ES2022-97607

**Guangdong Zhu** - *National Renewable Energy Laboratory*

### Mitigation of Leakage and Water Ingress for a Promising Phase Change Material (PCM) Containing Polyethylene Glycol (PEG)

Technical Paper Publication: ES2022-85563

**Kerry Rippy** - *National Renewable Energy Laboratory*, **Judith Vidal** - *National Renewable Energy Laboratory*, **Shuang Cui** - *University of Texas at Dallas*, **Sumanjeet Kaur** - *Lawrence Berkley National Laboratory*

### Adapting Molten Salt Thermal Energy Storage Technology for Behind-the-Meter Power-to-Heat Applications

Technical Presentation Only: ES2022-81523

**Nicholas Annejohn** - *McGill University*, **Melanie Tetreault-Friend** - *McGill University*

### Implementation of Thermal Energy Storage in Combined Cooling, Heating, and Power (CCHP) Systems

Technical Presentation Only: ES2022-91162

**Kibria Roman** - *State University of New York at Canton*, **Fardin Ishtiaq** - *Bangladesh University of Engineering and Technology*, **Maahi M. Talukder** - *Virginia Tech*, **Hossain Azam** - *University of the District of Columbia*

### Impact of Heating Rates on Salt Hydrate Reactor Performance

Technical Presentation Only: ES2022-87867

**Bryan Kinzer** - *University of Michigan*, **An Pham** - *University of Michigan*, **Michael Craig** - *University of Michigan*, **Rohini Bala Chandran** - *University of Michigan*

# Technical Sessions

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## 05-02 SOLAR RECEIVERS I

2:00PM–3:40PM

SALON 5

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Session Chair: **Brian Fronk** - *Oregon State University*

### Estimating the Structural Life of High Temperature Concentrating Solar Power Components

Invited Speaker Presentation: ES2022-99090

**Mark Messner** - *Argonne National Laboratory*

### CFD Based Design Optimization of Multiple Helical Swirl-Inducing Fins for Concentrated Solar Receivers

Technical Paper Publication: ES2022-80317

**Bharath Pidaparathi** - *University of Arizona*, **Samy Missoum** - *University of Arizona*, **Ben Xu** - *Mississippi State University*

### Multiphysics Numerical Study of Solar Receiver Tube for Enhanced Thermal Efficiency and Durability in Concentrated Solar Power Tower Plant

Technical Paper Publication: ES2022-81009

**Shawn Hatcher** - *Mississippi State University*, **Rajan Khadka** - *Mississippi State University*, **Bharath Pidaparathi** - *University of Arizona*, **Samy Missoum** - *University of Arizona*, **Peiwen Li** - *University of Arizona*, **Ben Xu** - *Mississippi State University*

### Modeling the Efficiency of an Ambient Pressure, Mesoporous Silica-Based Linear Receiver for Parabolic Trough Collectors

Technical Presentation Only: ES2022-91127

**Zachary Berquist** - *University of Michigan*, **Andrej Lenert** - *University of Michigan*

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## 09-01 SOLAR DESALINATION AND INDUSTRIAL PROCESS HEAT

4:00PM–5:40PM

SALON 4

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Session Chair: **Luke Venstrom** - *Valparaiso University*

### Prospects for Distributed Solar Desalination With Energy Storage

Invited Speaker Presentation: ES2022-81647

**Akanksha Menon** - *Georgia Institute of Technology*

### A Hybrid Membrane-Thermal Desalination System that Harnesses Solar Energy for Clean Water Production

Technical Presentation Only: ES2022-81644

**Akanksha Menon** - *Georgia Institute of Technology*

### Emissions Abatement of Pepper Roasting Utilizing a Concentrating Solar Tower Thermal Heat Source

Technical Paper Publication: ES2022-81495

**Kenneth M. Armijo** - *Sandia National Laboratories*, **Aaron Overacker** - *Sandia National Laboratories*, **Hector Mendoza** - *Sandia National Laboratories*, **Dimitri Madden** - *Sandia National Laboratories*, **Daniel Ray** - *Sandia National Laboratories*, **Luis Garcia-Maldonado** - *Sandia National Laboratories*, **Kenneth I. Armijo** - *Armijo Farms*, **Randolph Montoya** - *Sandia National Laboratories*

### Sintering Behavior of Lunar Soil Heated by Indirect and Direct Concentrated Sunlight Behavior of Lunar Soil Heated by Indirect and Direct Concentrated Sunlight

Technical Paper Publication: ES2022-81630

**Diprajit Biswas** - *University of Maine*, **Tom Cox** - *University of Maine*, **Justin Lapp** - *University of Maine*

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## 10-01 ALTERNATIVE ENERGY CONVERSION TECHNOLOGIES I

4:00PM–5:40PM

SALON 3

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Session Chair: **Hamidreza Najafi** - *Florida Institute of Technology*

### A Novel Hydrogen Economy Based on Electrochemical Cells Fully Integrated With Fossil Fuel Assets and Wastewater Resources

Technical Paper Publication: ES2022-80238

**Lateef Jolaoso** - *University of Oklahoma*, **Javad Asadi** - *University of Oklahoma*, **Chuancheng Duan** - *Kansas State University*, **Pejman Kazempoor** - *University of Oklahoma*

### Performance Study of a High Temperature Proton Exchange Membrane Fuel Cell at Different Operating Conditions

Technical Presentation Only: ES2022-89339

**Prantik Roy Chowdhury** - *North Dakota State University*, **Adam Gladen** - *North Dakota State University*

## Optimizing and Modelling Performance Parameters of IC Engine Fueled With Palm-Castor Biodiesel and Diesel Blends Combination Using RSM, ANN, MOORA and WASPAS Technique

Technical Paper Publication: ES2022-81146

David Samuel - Federal University of Petroleum Resources, Venkateshwar Reddy Pathapalli - Vardhaman College of Engineering, Christopher Enweremadu - University of South Africa, Science Campus, Florida

## Numerical Simulation and Experimental Validation of Thermoacoustic Engine Simulation and Experimental Validation of Thermoacoustic Engine

Technical Paper Publication: ES2022-85821

Ussama Ali - Khalifa University of Science and Technology, Yara Almasalmeh - Khalifa University of Science and Technology, Sufian Abedrabbo - Khalifa University of Science and Technology, Md Islam - Khalifa University of Science and Technology, Isam Janajreh - Khalifa University of Science and Technology

## Scalable and High-Performance Core-Shell Microparticle Embedded Polymer Coating for Thermal-Controllable Passive Radiative Cooling

Technical Paper Publication: ES2022-80943

Siru Chen - City University of Hong Kong, Aiqiang Pan - City University of Hong Kong, Kaixin Lin - City University of Hong Kong, Hau Him Lee - City University of Hong Kong, Tsz Chung Ho - City University of Hong Kong, Chi Yan Tso - City University of Hong Kong

## 05-03 CSP HEAT EXCHANGERS I

4:00PM-5:40PM

SALON 5

Session Chair: Brantley Mills - Sandia National Laboratories

## Experimental Optimization of Packing Structures and Investigation of Particle Hydrodynamics in a Gas-Particle Trickle Flow Heat Exchanger for Application in CSP Plants

Technical Paper Publication: ES2022-85556

Markus Reichart - German Aerospace Center - Institute of Solar Research, Alexander Hirt - German Aerospace Center - Institute of Solar Research, Martina Neises-Von Puttkamer - German Aerospace Center - Institute of Solar Research, Robert Pitz-Paal - German Aerospace Center - Institute of Solar Research

## Gen3 Concentrating Solar Power Developments in Moving Packed-Bed Heat Exchanger Technology

Technical Presentation Only: ES2022-89203

Kevin Albrecht - Sandia National Laboratories, Dereje Amogne - Vacuum Process Engineering, Ashley Byman - Solex Energy Science, David Moon - Solex Energy Science, Neville Jordison - Solex Energy Science, Clifford Ho - Sandia National Laboratories

## Assessing Parasitic Losses in Narrow-Channel, Fluidized-Bed Particle-sCO<sub>2</sub> Heat Exchangers for Next Generation CSP Plants

Technical Presentation Only: ES2022-91450

Winfred Arthur-Arhin - Colorado School of Mines, Jesse Fosheim - Colorado School of Mines, Azariah Thompson - Colorado School of Mines, Gregory Jackson - Colorado School of Mines

## Development of Segmented Heat Transfer Model for Reacting Particle-to-Supercritical Carbon Dioxide Heat Exchanger

Technical Presentation Only: ES2022-81817

Bryan J. Sieferting - Oregon State University, Muhammad Umer - Oregon State University, Brian Fronk - Oregon State University, Ellen B. Stechel - Arizona State University

## Experimental Investigation of a 50kw Particle-Based Shell-and-Tube Heat Exchanger Suitable for Concentrating Solar Power Applications

Technical Presentation Only: ES2022-85470

Nader S. Saleh - King Saud University, Shaker Alaqel - King Saud University, Rageh Saeed - King Saud University, Eldwin Djajadiwinata - King Saud University, Abdulelah Alswaiyd - King Saud University, Hany Al-Ansary - King Saud University, Zeyad Al-Suhaibani - King Saud University, Abdelrahman El-Leathy - King Saud University, Syed Danish - King Saud University, Muhammad Sarfraz - Georgia Institute of Technology, Sheldon Jeter - Georgia Institute of Technology

**TUESDAY, JULY 12, 2022**

**02-03 SUSTAINABLE COOLING AND HEATING SYSTEMS I**  
**10:30AM-12:10PM**

**SALON 3**

Session Chair: **Wahiba Yaici** - *Natural Resources Canada / CanmetENERGY Research Centre*

### **Performance Measurement and Verification of Variable-Speed Packaged Rooftop Units**

Technical Paper Publication: ES2022-85256

**Weimin Wang** - *University of North Carolina at Charlotte*, **Srinivas Katipamula** - *Pacific Northwest National Laboratory*, **Ronald Underhill** - *Pacific Northwest National Laboratory*

### **Development and Characterization of Inexpensive Methods for Fabricating Adsorbent-Coated Microchannels for Building Energy Systems Applications**

Technical Presentation Only: ES2022-87907

**Darshan Pahinkar** - *Florida Institute of Technology*, **Nitish Chauhan** - *Florida Institute of Technology*, **Nicolas Lohay** - *Florida Institute of Technology*

### **A Novel and Versatile Experimental Investigation of Water Breakthrough for Adsorption Based Building Cooling Systems**

Technical Presentation Only: ES2022-88007

**Darshan Pahinkar** - *Florida Institute of Technology*, **Faraz Ege** - *Florida Institute of Technology*

### **Can Heat-Pumps Provide Routes to Decarbonization of Building Thermal Control in the US Midwest?**

Technical Presentation Only: ES2022-90615

**Austin Doak** - *University of Iowa*, **Charles Stanier** - *University of Iowa*, **Jerry Anthony** - *University of Iowa*, **h.s. Udaykumar** - *University of Iowa*

### **Comparison of Solar Thermal Collectors and Solar PV Heat Pump Systems**

Technical Paper Publication: ES2022-81560

**Frederick Mitri** - *California State Polytechnic University*, **Kevin Anderson** - *California State Polytechnic University*

**03-02 HIGH TEMPERATURE THERMAL ENERGY STORAGE**

**10:30AM-12:10PM**

**SALON 4**

Session Chair: **Like Li** - *Mississippi State University*

### **Low-Cost Particle of Thermal Storage Energy for Concentrated Solar Power**

Invited Speaker Presentation: ES2022-78077

**Kyu Bum Han** - *Advanced Materials Scientia LLC*, **Zhiwen Ma** - *National Renewable Energy Laboratory*, **Patrick Davenport** - *National Renewable Energy Laboratory*, **Eunjin Jeon** - *Advanced Materials Scientia LLC*, **Korey Cook** - *National Renewable Energy Laboratory*, **Brenda Payan** - *University of Utah*, **Kimberly Watts** - *University of Utah*, **Jason Schirck** - *Purdue University*

### **Design and Analysis of a Concentrating Solar Power Plant and Pumped-Storage Facility (CSP/PSF)**

Technical Presentation Only: ES2022-97583

**Kevin Anderson** - *California State Polytechnic University*, **Frederick Mitri** - *California State Polytechnic University*

### **Experimental Observations of a High-Temperature Air-Tight Thermal Energy Storage Tank in Particle-Based CSP Systems**

Technical Presentation Only: ES2022-85365

**Shaker Abdullah** - *King Saud University*, **Nader S. Saleh** - *King Saud University*, **Rageh Saeed** - *King Saud University*, **Eldwin Djajadiwinata** - *King Saud University*, **Abdulah Alswaid** - *King Saud University*, **Hany Al-Ansary** - *King Saud University*, **Abdelrahman El-Leathy** - *King Saud University*, **Zeyad Al-Suhaibani** - *King Saud University*, **Syed Danish** - *King Saud University*, **Muhammad Sarfraz** - *Georgia Institute of Technology*, **Sheldon Jeter** - *Georgia Institute of Technology*



## High-Temperature Thermal Energy Storage Based on Conductive Ceramic Composites for Decarbonizing Heat and Electricity

Technical Presentation Only: ES2022-97671

**Lin Yang** - Lawrence Berkeley National Laboratory, **Nathaniel Weger** - Lawrence Berkeley National Laboratory, **Peng Peng** - Lawrence Berkeley National Laboratory, **Akanksha Menon** - Georgia Institute of Technology, **Qiye Zheng** - Lawrence Berkeley National Laboratory, **Chaochao Dun** - Lawrence Berkeley National Laboratory, **Clément Messeri** - University of California, Berkeley, **Drew Lilley** - Lawrence Berkeley National Laboratory, **Jeff Urban** - Lawrence Berkeley National Laboratory, **Sumanjeet Kaur** - Lawrence Berkeley National Laboratory, **Hanna Breunig** - Lawrence Berkeley National Laboratory, **Ravi Prasher** - Lawrence Berkeley National Laboratory, **Sean Lubner** - Lawrence Berkeley National Laboratory

## Characterization of Solid Particles to Be Used as Storage as Well as Heat Transfer Media in CSP System

Technical Presentation Only: ES2022-85487

**Rageh Saeed** - King Saud University, **Eldwin Djajadiwinata** - King Saud University, **Shaker Alaqel** - King Saud University, **Nader S. Saleh** - King Saud University, **Abdulelah Alswaiyd** - King Saud University, **Hany Al-Ansary** - King Saud University, **Abdelrahman El-Leathy** - King Saud University, **Syed Danish** - King Saud University, **Zeyad Al-Suhaibani** - King Saud University, **Muhammad Sarfraz** - Georgia Institute of Technology, **Sheldon Jeter** - Georgia Institute of Technology

## 05-04 CSP HEAT EXCHANGERS II

10:30AM-12:10PM

SALON 5

Session Chair: **Nathan Schroeder** - Sandia National Laboratories

## Multi-Objective Optimization of a Bi-Metal High Temperature Recuperator for Application in Concentrating Solar Power

Technical Paper Publication: ES2022-81388

**Jacob Bryan** - Utah State University, **Aiden Meek** - Utah State University, **Hailei Wang** - Utah State University

## A Scalable Compact Additively-Manufactured Molten-Salt to Supercritical Carbon Dioxide Heat Exchanger for Solar Thermal Application

Technical Paper Publication: ES2022-84122

**Ines-Noelly Tano** - University of California, Davis, **Erfan Rasouli** - University of California, Davis, **Tracey Ziev** - Carnegie Mellon University, **Junwon Seo** - Carnegie Mellon University, **Nicholas Lamprinakos** - Carnegie Mellon University, **Parth Vaishnav** - University of Michigan, **Anthony Rollett** - Carnegie Mellon University, **Ziheng Wu** - Carnegie Mellon University, **Vinod Narayanan** - University of California, Davis

## Thermal-Mechanical Analysis of an Additive Manufacturing Ceramic Heat Exchanger for High-Temperature Recuperator in a sCO<sub>2</sub> Power System

Technical Paper Publication: ES2022-85438

**Zhiwen Ma** - National Renewable Energy Laboratory, **Sameer Jape** - Argonne National Laboratory, **Patrick Davenport** - National Renewable Energy Laboratory, **David Lipke** - Missouri University of Science and Technology

## Comparison of Pump Curves Operating With Water and Supercritical Carbon Dioxide

Technical Presentation Only: ES2022-81460

**Francisco Alvarez** - Sandia National Laboratories, **Hendrik Frederik Laubscher** - Sandia National Laboratories, **Paul Anderson** - Teikoku USA Inc., **John Maloney** - Teikoku USA Inc

## 05-05 SOLAR COLLECTORS

2:00PM-3:40PM

SALON 5

Session Chair: **Matthew Bauer** - U.S. Department of Energy

## Components & Controls Gap Assessment for Reducing CSP LCOE and LCOH

Technical Presentation Only: ES2022-97676

**Kenneth Armijo** - Sandia National Laboratories

## An International Heliostat Consortium (Heliocoin) to Advance Heliostat Technologies to Next Generation: Metrology & Standards

Technical Presentation Only: ES2022-97606

**Guangdong Zhu** - National Renewable Energy Laboratory

# Technical Sessions

## Mirror Degradation Modeling Using Xenon Arc Lamp Exposure

Technical Presentation Only: ES2022-97661

Tucker Farrell - *National Renewable Energy Laboratory*

## Energy and Exergy Analysis of a Developed Compound Parabolic Collector Using a Pumped Solar Water Heating System

Technical Paper Publication: ES2022-85481

Kabo Kashamba - *University of Botswana*, Tlhalefo Letsholo - *University of Botswana*, Okatoseng Masoso - *University of Botswana*, Kevin Nwaigwe - *University of Botswana*

## 06-02 SOLAR THERMOCHEMICAL FUELS

2:00PM–3:40PM

SALON 4

Session Chair: **Brendan Bulfin** - *ETH Zurich*

## Experimental Demonstration of a High-Temperature Heat Recovery System for Solar Redox Reactors

Invited Speaker Presentation: ES2022-87564

Alon Lidor - *ETH Zürich*, Leo Zimmermann - *ETH Zürich*, Philipp Haueter - *ETH Zürich*, Aldo Steinfeld - *ETH Zürich*

## Design and Operational Guidelines of Solar-Driven Catalytic Conversion of CO<sub>2</sub> and H<sub>2</sub> to Fuels

Invited Speaker Presentation: ES2022-90735

Sha Li - *École Polytechnique Fédérale de Lausanne*, Sophia Haussener - *École Polytechnique Fédérale de Lausanne*

## Low Temperature, Solar-Driven Chemical-Looping Reforming With High Selectivity and Conversion Using Catalytically Enhanced Ceria

Technical Presentation Only: ES2022-84263

Caroline Hill - *University of Florida*, Rachel Robbins - *University of Florida*, Philipp Furler - *Synhelion SA*, Simon Ackermann - *Synhelion SA*, Jonathan Scheffe - *University of Florida*

## Design of a Combined PID Controller to Regulate the Temperature Inside a High-Temperature Tubular Solar Reactor

Technical Paper Publication: ES2022-85604

Assaad Alsahlani - *Purdue University Northwest*, Kelvin Randhir - *Michigan State University*, Michael Hayes - *Michigan State University*, Philipp Schimmels - *Michigan State University*, Nesrin Ozalp - *Purdue University Northwest*, James Klausner - *Michigan State University*

## 10-02 ALTERNATIVE ENERGY CONVERSION TECHNOLOGIES II

2:00PM–3:40PM

SALON 3

Session Chair: **Julia Haltiwanger Nicodemus** - *Lafayette College*

## Comparative Investigation of Double-Skin Façade (DSF) Systems Design for Enhanced Energy Performance of Commercial Building

Technical Presentation Only: ES2022-90752

Tien Tran Nhat - *Hanbat National University*, Hyo-Mun Lee - *Hanbat National University*, Goo Seomun - *Hanbat National University*, Jong-Ho Yoon - *Hanbat National University*, Dong-Su Kim - *Hanbat National University*

## Optimal Bi-Annual Tilt Angles and Optimal Tilt Transition Timing for Fixed Tilt Arrays in the United States

Technical Paper Publication: ES2022-84344

Essa Alhamer - *University of Dayton*, Addison Grigsby - *University of Dayton*, Rydge Mulford - *University of Dayton*

## Interchangeability of Syngas Derived From Coal-Biomass Co-Gasification With Natural Gas: Conditions for Syngas Integration in Industrial Processes

Technical Paper Publication: ES2022-81584

Daniel Quintero - *Universidad del Norte*, Lesme Corredor - *Universidad del Norte*, Arturo González - *Universidad del Norte*

## A Comparison of the Fuel Economy Estimates of a Drive Cycle Developed Using the Road Load Energy Criterion and the Actual On-Road Fuel Economy in a Private Vehicle in the Philippines

Technical Paper Publication: ES2022-85434

Robert Michael Corpus - *Polytechnic University of the Philippines*, Robert James Lomotan - *Collegio De Muntinlupa*, Peter Vasquez - *Collegio De Muntinlupa*

## Study of the Piezoelectric Properties of UV-Selective Optically Transparent Zn(O,S) Based Solar Cells

Technical Paper Publication: ES2022-84373

Iyad Hijazi - Marshall University, Rui Xie - Marshall University

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## 14-01 OCEAN, HYDRO, AND WIND POWER TECHNOLOGIES

4:00PM–5:40PM

INDIA A

Session Chair: Justin Lapp - University of Maine

## Liquid Metal Battery Storage Integrated Into an Offshore Wind Turbine

Technical Presentation Only: ES2022-80611

Juliet Simpson - University of Virginia, Garrett Hanrahan - University of Virginia, Eric Loth - University of Virginia, Gary Koenig - University of Virginia, Donald Sadoway - Massachusetts Institute of Technology

## An Approximation of Using Vertical-Axis Tidal Turbine for Water Desalination in the Suez Canal Waterway

Technical Paper Publication: ES2022-85533

Ahmed Gharib Yosry - Port Said University, Rodolfo Espina Valdés - University of Oviedo, Eduardo Blanco Marigorta - University of Oviedo, Eduardo Álvarez - University of Oviedo

## Numerical Analysis of Flow Over Slitted Cylinder and Experimental Validation Using Soap-Film Technique

Technical Paper Publication: ES2022-85827

Isam Janajreh - Khalifa University of Science and Technology, Hussain Hassan - Khalifa University of Science and Technology, Hamid Ait Abderrahmane - Khalifa University of Science and Technology, Ussama Ali - Khalifa University of Science and Technology, Md Islam - Khalifa University of Science and Technology

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## 01-02 NEXUS: ENERGY, WATER AND CLIMATE II

4:00PM–5:40PM

SALON 3

Session Chair: Shuang Cui - University of Texas at Dallas

## Design and Construction of an Unmanned Aerial Vehicle (UAV) for Urban Air Quality Monitoring

Technical Presentation Only: ES2022-91985

Yudaya Nassali Nangoma - Makerere University

## Distributed Energy Systems Design Optimization Based on Life Cycle Environmental and Economic Impacts

Technical Paper Publication: ES2022-85730

Krishna Maharjan - Mississippi State University, Jian Zhang - University of Wisconsin-Green Bay, Heejin Cho - Mississippi State University, Yang Chen - Oak Ridge National Laboratory

## Development of a Controlled Heating System for Rural Houses, in Peruvian Highlands, Using Phase Change Materials (PCM)

Technical Presentation Only: ES2022-81880

Juan A. Joyo Taype - Universidad de Ingeniería y Tecnología, Carlos V. Escobedo Molina - Universidad de Ingeniería y Tecnología, Renato A. Corahua Benites - Universidad de Ingeniería y Tecnología, Carlos A. Rios Perez - Universidad de Ingeniería y Tecnología

## Compost Waste Heat to Power Organic Rankine Cycle Design and Analysis

Technical Paper Publication: ES2022-81531

Frederick Mitri - California State Polytechnic University, William Dennis - California State Polytechnic University, Kevin Anderson - California State Polytechnic University, Wael Yassine - California State Polytechnic University

## Characterization of Flow Fields in an Enclosure in Open Channel Flow Using PIV

Technical Presentation Only: ES2022-87994

Mohammad Rajib Rony - North Dakota State University, Adam Gladen - North Dakota State University

# Technical Sessions

## 05-06 CSP SYSTEMS

4:00PM–5:40PM

SALON 5

Session Chair: **Matthew Bauer** - *U.S. Department of Energy*

### Concentrating Solar Thermal-Power and Long Duration Energy Storage Using Stable, Low-Cost Solid Particles

Invited Speaker Presentation: ES2022-93684

Zhiwen Ma - *National Renewable Energy Laboratory*

### Preliminary Thermal and Structural Analysis of High Temperature Multilayered Thermal Energy Storage Bin in a Particle Heating Receiver Based Thermal Power Plants

Technical Paper Publication: ES2022-85327

Muhammad Mansoor Sarfraz - *Georgia Institute of Technology*, Shaker Alaqel - *King Saud University*, Nader S. Saleh - *King Saud University*, Rageh Saeed - *King Saud University*, Eldwin Djajadiwinata - *King Saud University*, Abdulelah Alswaiyd - *King Saud University*, Kenzo Repole - *Onozo LLC*, Ryan Yeung - *Georgia Institute of Technology*, Syed Danish - *King Saud University*, Abdelrahman El-Leathy - *King Saud University*, Zeyad Al-Suhaibani - *King Saud University*, Zeyad Almuthairi - *King Saud University*, Sheldon Jeter - *Georgia Institute of Technology*, Hany Al-Ansary - *King Saud University*

### The Results of the On-Sun Testing at King Saud University's Gas-Turbine Particle-Based Power Tower Test Facility

Technical Presentation Only: ES2022-85355

Shaker Al-Aqel - *King Saud University*, Nader Saleh - *King Saud University*, Rageh Saeed - *King Saud University*, Eldwin Djajadiwinata - *King Saud University*, Abdulelah Alswaiyd - *King Saud University*, Hany Al-Ansary - *King Saud University*, Abdelrahman El-Leathy - *King Saud University*, Zeyad Al-Suhaibani - *King Saud University*, Syed Danish - *King Saud University*, Muhammad Sarfraz - *Georgia Institute of Technology*, Sheldon Jeter - *Georgia Institute of Technology*

### Construction and Commissioning of a 1 Mw Thermal Supercritical Carbon Dioxide Cooling Loop

Technical Presentation Only: ES2022-78106

Francisco Alvarez - *Sandia National Laboratories*, Hendrik Frederik Laubscher - *Sandia National Laboratories*

## 06-03 SOLAR REACTION ENGINEERING

4:00PM–5:40PM

SALON 4

Session Chair: **Alon Lidor** - *ETH Zurich*

### Solar Reduction and N2 Purification via Directly Irradiated Inclined Flow and Packed Bed Particle Reactors

Technical Presentation Only: ES2022-91110

H. Evan Bush - *Sandia National Laboratories*, Kevin Albrecht - *Sandia National Laboratories*, Matthew Kury - *Sandia National Laboratories*, Andrea Ambrosini - *Sandia National Laboratories*

### Redox Chemical Looping of Strontium Iron Perovskites for Oxygen and Nitrogen Production

Technical Presentation Only: ES2022-88958

Brendan Bulfin - *ETH Zurich*, Stefano Capstick - *ETH Zurich*, Aldo Steinfeld - *ETH Zurich*

### Computational Screening and Experimental Validation of Binary and Ternary Metal Nitrides for the Solar-Driven Thermochemical Production of Green Ammonia

Technical Presentation Only: ES2022-89404

Daniel Notter - *ETH Zurich*, Mariá-Elena Gálvez - *Sorbonne Université*, Brendan Bulfin - *ETH Zurich*, Aldo Steinfeld - *ETH Zurich*

### Pore-Engineering for Enhanced Performance in Thermochemistry

Technical Presentation Only: ES2022-87884

Xiaoyu Dai - *Ecole Polytechnique Federale de Lausanne*, Sophia Haussener - *Ecole Polytechnique Federale de Lausanne*

### Modeling of Thermochemical Reaction-Transport Coupling in High-Temperature Solar Reactors for Energy Storage

Technical Presentation Only: ES2022-81211

David Korba - *Mississippi State University*, Kelvin Randhir - *Michigan State University*, Joerg Petrasch - *Michigan State University*, James Klausner - *Michigan State University*, Nick Auyeung - *Oregon State University*, Like Li - *Mississippi State University*

## WEDNESDAY, JULY 13, 2022

### 02-04 SUSTAINABLE COOLING AND HEATING SYSTEMS II

10:30AM–12:10PM

SALON 3

Session Chair: **Weimin Wang** - *The University of North Carolina at Charlotte*

#### **The Effect of Pitch on Heat Transfer to an Immersed Heat Exchanger in a Solar Thermal Storage Tank With and Without a Baffle**

Technical Paper Publication: ES2022-82581

**Julia Haltiwanger Nicodemus** - *Lafayette College*, **Joshua Smith** - *Lafayette College*, **Alexander Holme** - *Lafayette College*, **Sarah Johnson** - *Lafayette College*, **Kyle Petitt** - *Lafayette College*

#### **Net-Zero Energy Home Design Using Photovoltaic-Based Distributed Energy Generation and Multi-Functional Variable Refrigerant Flow Systems Integrated With Thermal Energy Storage**

Technical Paper Publication: ES2022-84345

**Dongsu Kim** - *Hanbat National University*, **Kelly Tran** - *Mississippi State University*, **Jaeyoon Koh** - *LG Electronics U.S.A.*, **Heejin Cho** - *Mississippi State University*

#### **Thermodynamic Modeling and Simulation of an Organic Rankine Cycle-Ejector Heat Pump-Based Trigeneration System Using a Zeotropic Mixture**

Technical Paper Publication: ES2022-80868

**Wahiba Yaici** - *Natural Resources Canada/CanmetENERGY*, **Evgueniy Entchev** - *Natural Resources Canada/CanmetENERGY*, **Michela Longo** - *Politecnico di Milano*

#### **Air Handling Unit Shutdowns During Scheduled Unoccupied Hours: U.S. Commercial Building Stock Prevalence and Energy Impact**

Technical Paper Publication: ES2022-85694

**Christopher Caradonna** - *National Renewable Energy Laboratory*, **Kelsea Dombrovski** - *National Renewable Energy Laboratory*

#### **Development of Electrified Transcritical R744 Heat Pump Systems for Northeastern Winter Markets**

Technical Presentation Only: ES2022-90241

**David Garraway** - *The City College of New York*, **S M Abdur Rob** - *The City*

*College of New York*, **Prathap Ramamurthy** - *The City College of New York*, **Jorge Gonzalez-Cruz** - *The City College of New York*

### 03-03 COMPRESSED AIR & THERMOCHEMICAL ENERGY STORAGE

10:30AM–12:10PM

SALON 4

Session Chair: **Rohini Bala Chandran** - *University of Michigan*

#### **Numerical Simulation of Spray-Cooled Isothermal Compressed Air Energy Storage**

Technical Presentation Only: ES2022-79414

**Juliet Simpson** - *University of Virginia*, **Chao (Chris) Qin** - *University of Virginia*, **Eric Loth** - *University of Virginia*

#### **Monolithic Porous Structures of Ca-Mn-Based Perovskites for Thermochemical Energy Conversion**

Invited Speaker Presentation: ES2022-88031

**Mathias Pein** - *German Aerospace Center - DLR, Institute of Future Fuels*, **Christos Agrafiotis** - *German Aerospace Center - DLR, Institute of Future Fuels*, **Martin Roeb** - *German Aerospace Center - DLR, Institute of Future Fuels*, **Christia Sattler** - *German Aerospace Center - DLR, Institute of Future Fuels*

#### **High Temperature Discharge of Solid-State Thermochemical Energy Storage Particles in a Hybrid Fluidized-Moving Bed Reactor: Preliminary Design**

Technical Presentation Only: ES2022-85723

**Juvenal Alejandro Ortiz-Ulloa** - *Oregon State University*, **Fuqiong Lei** - *Oregon State University*, **Lucas Freiberg** - *Oregon State University*, **Nesrin Ozalp** - *Purdue University Northwest*, **Like Li** - *Mississippi State University*, **Kelvin Randhir** - *Michigan State University*, **Joerg Petrasch** - *Michigan State University*, **Nick Auyeung** - *Oregon State University*, **James Klausner** - *Michigan State University*

#### **Modeling of High-Temperature Oxidation in a Moving-Bed Reactor for Thermochemical Energy Storage,**

Invited Speaker Presentation: ES2022-81660

**David Korba** - *Mississippi State University*, **Kelvin Randhir** - *Michigan State University*, **Joerg Petrasch** - *Michigan State University*, **James Klausner** - *Michigan State University*, **Nick Auyeung** - *Oregon State University*, **Like Li** - *Mississippi State University*



# Technical Sessions

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**05-07 SOLAR RECEIVERS II**

**10:30AM–12:10PM**

**SALON 5**

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Session Chair: **Matthew Bauer** – *U.S. Department of Energy*

**Thermal Performance of Commercial Falling Particle Receivers at Different Scales**

Technical Presentation Only: ES2022-81023

**Brantley Mills** - *Sandia National Laboratories*, **Jae Bok Lee** - *Sandia National Laboratories*, **Luis González-Portillo** - *Universidad Politécnica de Madrid*, **Kevin Albrecht** - *Sandia National Laboratories*, **Clifford Ho** - *Sandia National Laboratories*

**Modeling of an Indirect Fluidized Bed Particle Receiver for Concentrating Solar Power**

Technical Presentation Only: ES2022-85312

**Keaton Brewster** - *Colorado School of Mines*, **Luca Imponenti** - *Solar Dynamics, LLC*, **Jesse Fosheim** - *Colorado School of Mines*, **Gregory Jackson** - *Colorado School of Mines*

**Characterization of Particle Curtain Forward Translation in Multistage Release Falling Particle Receivers**

Technical Presentation Only: ES2022-87487

**Nathan Schroeder** - *Sandia National Laboratories*, **Brantley Mills** - *Sandia National Laboratories*, **Clifford Ho** - *Sandia National Laboratories*

**Thermal Performance of Multistage Falling Particle Receivers at Various Commercial Scales**

Technical Presentation Only: ES2022-88613

**Jae Bok Lee** - *Sandia National Laboratories*, **Brantley Mills** - *Sandia National Laboratories*



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**Boeing will be exhibiting in the Liberty Foyer, Ballroom Level, Monday, and Tuesday from 10:00AM–4:00PM, please stop by.**

### Boeing Launches One-Stop Benefits Resource

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TRACK	TRACK CHAIR(S)	TRACK CO-CHAIR(S)
1. Nexus: Energy, Water and Climate	Shuang Cui, University of Texas at Dallas	Xin Jin, National Renewable Energy Laboratory
2. Sustainable Buildings and Cities	Jian Zhang, University of Wisconsin-Green Bay	Menglian Zheng, Zhejiang University
3. Energy Storage	Rohini Bala Chandran, University of Michigan	Like Li, Mississippi State University
5. Concentrating Solar Power	Mathew Bauer, U.S. Department of Energy	Brantley Mills, Sandia National Labs
6. Solar Chemistry	Brendan Bulfin, ETH-Zurich	Asmaa Eltayeb, German Aerospace Center (DLR)
9. Solar Desalination and Industrial Process Heat	Akanksha Menon, Georgia Institute of Technology	
10. Alternative Energy Conversion Technologies	Wahiba Yaici, CanmetENERGY Research Centre	Aggrey Mwesigye, University of Calgary, Han Hu, University of Arkansas, Jun Xu, University of North Carolina at Charlotte
14. Ocean, Hydro and Wind Power Technologies	Justin Lapp, University of Maine	



# Session Organizers

SESSION	TRACK/SESSION PRIMARY CHAIR
01-01 Nexus: Energy, Water and Climate I	Shuang Cui, University of Texas at Dallas
01-02 Nexus: Energy, Water and Climate II	Shuang Cui, University of Texas at Dallas
02-01 Sustainable Buildings and Cities I	Iyad Hijazi, Marshall University
02-02 Sustainable Buildings and Cities II	Darshan Pahinkar, Florida Institute of Technology
02-03 Sustainable Cooling and Heating Systems I	Wahiba Yaici, Natural Resources Canada/CanmetENERGY Research Centre
02-04 Sustainable Cooling and Heating Systems II	Weimin Wang, UNC Charlotte
03-01 Energy Storage	Rohini Bala Chandran, University of Michigan
03-02 High Temperature Thermal Energy Storage	Like Li, Mississippi State University
03-03 Energy Storage	Rohini Bala Chandran, University of Michigan
05-01 High Temperature Metrology	Zachary Berquist, University of Michigan
05-02 Solar Receivers I	Brian Fronk, Oregon State University
05-03 CSP Heat Exchangers I	Brantley Mills, Sandia National Laboratories
05-04 CSP Heat Exchangers II	Nathan Schroeder, Sandia National Laboratories
05-05 Solar Collectors	Matthew Bauer, U.S. Department of Energy
05-06 CSP Systems	Matthew Bauer, U.S. Department of Energy
05-07 Solar Receivers II	Matthew Bauer, U.S. Department of Energy
06-01 Solar Thermochemical Hydrogen	Brendan Bulfin, ETH Zurich
06-02 Solar Thermochemical Fuels	Brendan Bulfin, ETH Zurich
06-03 Solar Reaction Engineering	Alon Lidor, ETH Zurich
09-01 Solar Desalination and Industrial Process Heat	Luke Venstrom, Valparaiso University
10-01 Alternative Energy Conversion Technologies I	Hamidreza Najafi, Florida Institute of Technology
10-02 Alternative Energy Conversion Technologies II	Julia Haltiwanger Nicodemus, Lafayette College
14-01 Ocean, Hydro and Wind Power Technologies	Justin Lapp, University of Maine

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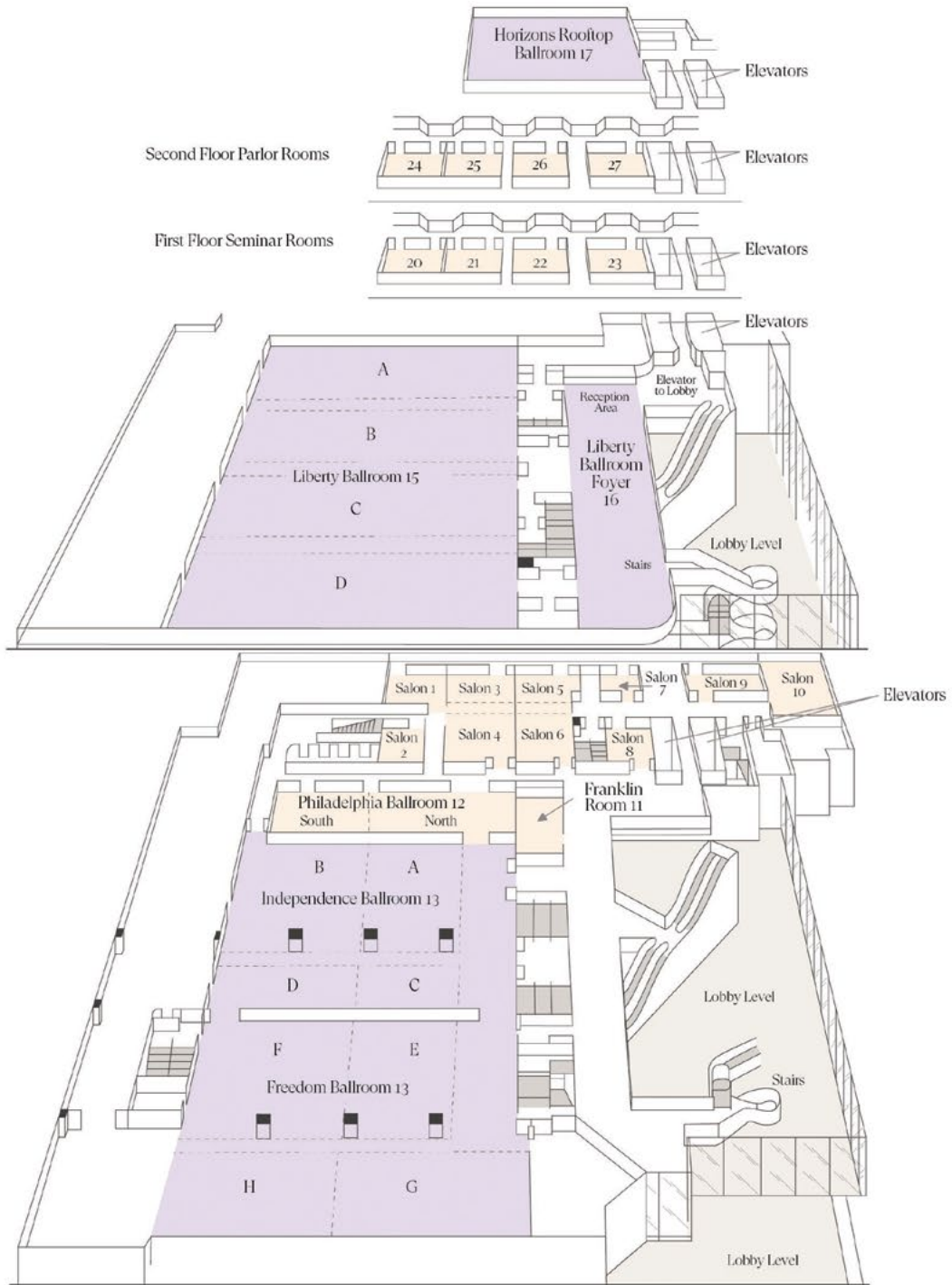
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# Hotel Floor Plan





# ASME 2022 ES

16th International Conference on Energy Sustainability  
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