THE 54th IEEE PHOTOVOLTAIC SPECIALISTS CONFERENCE

CALL FOR PAPERS

Area 1: Fundamentals and New Concepts for Future Technologies
Area 2: Chalcogenide Thin Film Solar Cells
Area 3: III-V Photovoltaic Devices and Space Solar Power
Area 4: Silicon Photovoltaic Materials and Devices
Area 5: Characterization Methods
Area 6: Perovskite and Organic Materials and Solar Cells
Area 7: PV Modules, Manufacturing, Systems and Applications
Area 8: Module and System Reliability
Area 9: Power Electronics and Grid Integration
Area 10: Solar Energy Meteorology
Area 11: PV Deployment, Policy and Sustainability
Area 12 Special Sessions: Industrial Perspective

Area 1: Fundamentals and New Concepts for Future Technologies

Area Chair: *Emily Warren, National Laboratory of the Rockies (formerly NREL), USA*
Co-Chair: *Rebecca Saive, University of Twente, Netherlands*

Sub-Area 1.1: Fundamental Conversion Mechanisms
Sub-Area 1.2: Novel Materials and Devices
Sub-Area 1.3: Advanced Light Management and Spectral Shaping

Area Description

Paradigm shifts in solar cell technology are invariably preceded by breakthroughs arising from basic scientific research. Area 1 comprises fundamental research and novel device concepts that will provide a platform for the development of future photovoltaic technologies. Papers are sought describing research in basic physical, chemical, and optical phenomena, studies of new materials and innovative device designs, as well as photon management methods. Subjects of particular interest include, but are not limited to, new materials for all parts of the photovoltaic device, advances in the understanding of basic PV architectures and phenomena, nanostructures, approaches for advanced optical management, new synthesis processes, and/or unconventional conversion mechanisms.

Sub-Area 1.1: Fundamental Conversion Mechanisms

Sub-Area Chair: Daniel Suchet, IPVF Ecole Polytechnique, France

This sub-area explores novel paradigms for solar energy conversion through both experimental and theoretical approaches. Research should focus on innovative physics, modeling, and early demonstrations of advanced conversion mechanisms. Topics of interest in this sub-area include:

- Multiple exciton generation and molecular singlet-fission
- Hot-carrier effects and protocols
- Intermediate band concepts and band alignment engineering
- Thermophotovoltaics, thermophotonics, and/or thermoradiative concepts
- Solar fuel generation and alternative energy storage mechanisms
- Fundamental thermodynamic studies related to solar energy

Sub-Area 1.2: Novel Materials and Devices

Sub-Area Chair: TBD

This sub-area focuses on the development of new absorber materials and device architectures. Abstracts submitted to this sub-area should focus on topics or materials that fall outside the scope of other areas and emphasize fundamental research and novel concepts not yet explored in mainstream photovoltaics. Topics of interest in this sub-area include:

- Two-dimensional materials and devices, nanowires, and quantum dots
- Earth-abundant absorber materials and perovskite-inspired materials

- Carrier-selective contacts and transparent conducting materials
- Tandem and multijunction solar cells with unconventional materials
- Advanced growth, synthesis, and thin-film deposition techniques
- Cost-reduction strategies and material reusability

Sub-Area 1.3: Advanced Light Management and Spectral Shaping

Sub-Area Chair: Louise Hirst, University of Cambridge, UK

This sub-area addresses novel concepts to maximize light harvesting and photon energy utilization in solar cells. Research should focus on theory, modeling and experimental demonstrations of advanced optical conversion mechanisms. Topics of interest in this sub-area include:

- Anti-reflection coatings and spectrum splitting
- Textured light-trapping surfaces and interfaces
- Luminescent systems for up/down conversion and quantum cutting
- Photonic and plasmonic structures
- Photon recycling and angular restriction techniques
- Advanced optoelectronic modeling approaches and techniques.

Area 2: Chalcogenide Thin Film Solar Cells

Area Chair: *Aaron Arehart, Ohio State University, USA*
Co-Chairs: *Chris Ferekides, University of South Florida, USA*

Sub-Area 2.1: Absorber Preparation and Material Properties
Sub-Area 2.2: Contacts, Windows, Interfaces, and Substrates
Sub-Area 2.3: Cell and Module Characterization – Analysis, Theory, and Modeling
Sub-Area 2.4: Chalcogenides for Tomorrow and Beyond – Tandems, Recyclability, and Future Innovations

Area Description
Chalcogenide thin-film solar cells have demonstrated remarkable progress over recent years both in record conversion efficiency (> 23%) and manufacturing volume (over 16 GWp in 2024). Combining low-cost, fast production with reliable field operation, chalcogenide thin-film solar cells have helped reduce the cost of PV-generated electricity. Area 2 brings the chalcogenide thin-film community together to present and discuss progress, challenges, and future research directions for CdTe, CuZnSnS, and CIGS and other thin-film photovoltaic materials and devices. The aim is to improve fundamental understanding, address performance loss at the cell and module level, and accelerate production. Topics range from fundamental and applied material science, computational/analytical results and in-depth characterization to device fabrication, manufacturing challenges, and future innovations.

Sub-Area 2.1: Absorber Preparation and Material Properties
Sub-Area Chair: TBD

Sub-area 2.1 captures progress in thin-film fabrication, material properties, and their relationship with device performance. Topics include experiment, theory, and characterization of:

- Morphology, phase coexistence, and microstructure
- Extended, point, and other bulk defects
- Transport properties
- Doping and bulk passivation
- Compositional gradients and homogeneity
- Influence of growth substrate, grain boundaries, and post-deposition treatments

Sub-Area 2.2: Contacts, Windows, Interfaces, and Substrates
Sub-Area Chair: TBD

Sub-area 2.2 advances understanding of contacts, buffer and window layers, interfaces, and growth substrates/superstrates and their effect on device performance. Please note some overlap with sub-areas 1.2 and 4.2. Topics include experiment, theory, and characterization of:

- Novel contact materials, carrier selective contacts

- Transparent conductors, moisture barriers, new or improved growth substrates
- Interface passivation strategies (chemical, field-effect)
- Light management techniques
- Cell scribing and interconnection in modules

Sub-Area 2.3: Cell and Module Characterization – Analysis, Theory, and Modeling
Sub-Area Chair: TBD

Sub-Area 2.3 complements topics addressed in sub-areas 2.1 and 2.2 through research discussion aimed at measurement, analysis, theory, and modelling of cells and modules. Please note some overlap with Area 5. Topics include:

- Novel and established characterization methods
- Device analysis that yields insight into internal operation
- 1D, 2D, and 3D modelling of current devices and studies that guide progress
- In-situ and in-line metrology, statistical data analysis, machine learning

Sub-Area 2.4: Thin-films for Tomorrow and Beyond – Tandems, Recyclability, and Future Innovations
Sub-Area Chair: TBD

Sub-area 2.4 provides a launchpad for discussion of next generation chalcogenide-based photovoltaics. Please note there is some overlap with Area 1. This sub-area solicits contributions for experimental and theoretical research for:

- Next-generation thin-film technologies
- Tandem and multijunction device applications
- Modules and material recyclability and sustainability (e.g., use of earth-abundant materials and reduced carbon emissions)
- Supply chain and feedstocks

Novel applications (e.g. lightweight/flexible, space, building-integrated, and low-dimensional)

Area 3: III-V Photovoltaic Devices and Space Solar Power

Area Chair: *Pilar Espinet-González, The Aerospace Corporation, USA*
Co-Chair: *Stephen Polly, RIT, USA*

Sub-Area 3.1: III-V Photovoltaic Cells
Sub-Area 3.2: III-V Cost Reduction Strategies & Terrestrial Applications
Sub-Area 3.3: Space Photovoltaic Modules, Systems, and Flight Experience
Sub-Area 3.4: Alternatives to III-V for Space Applications
Sub-Area 3.5: Photonic Power Converters

Area Description

Area 3 focuses on two main subjects: III-V photovoltaic devices and space power systems. III-V solar cells offer unparalleled photovoltaic conversion efficiency, an expansive palette of material properties, high absorption coefficients, resilience in extreme environments, as well as compatibility with a wide-range of growth and fabrication strategies. These attributes make III-Vs well-suited for a multitude of both terrestrial and space power applications. Area 3 covers all aspects of III-V materials including photovoltaic device and system design, growth, fabrication, characterization and reliability studies. Applications under discussion include concentrator photovoltaics (CPV), autonomous vehicle power, commercial solar electric vehicles, laser power beaming receivers, dismounted soldier power, consumer electronics, thermophotovoltaics, solar fuels generation, and biomedical energy harvesters. In the context of space power, topics such as flight experience, the characterization and impact of the space environment, and the development of innovative material system alternatives—including non-III-V options—are addressed.

Sub-Area 3.1: III-V Photovoltaic Cells

Sub-Area Chair: Margaret Stevens, Naval Research Laboratory, USA

Sub-Area 3.1 concentrates on all aspects of III-V photovoltaic development up to the device level. Topics of interest include, but are not limited to:

- Epitaxial growth
- Materials design, development and characterization
- Device-level modeling and characterization in single and multijunction devices including hybrid tandem/multijunctions with a focus on the III-V development
- Novel processing strategies (excluding low-cost strategies (see Area 3.2))
- Reliability and environmental effects testing from materials-to-device level

Sub-Area 3.2: III-V Cost Reduction Strategies & Terrestrial Applications
Sub-Area Chair: Theresa Saenz, National Laboratory of the Rockies (formerly NREL), USA

Topics of interest in this Sub-Area concern all aspects of cost reduction strategies for III-V photovoltaics at the materials, device, or module level. This Sub-Area also includes all terrestrial applications and systems that involve III-V photovoltaics. Topics of interest include:

- Substrate reuse
- Direct monolithic growth of III-Vs on low-cost templates
- High-throughput epitaxial growth and enhanced growth precursor utilization efficiency
- Low-cost device, array and module fabrication strategies
- Terrestrial conventional CPV and micro-CPV
- Transportation applications
- Underwater photovoltaics
- Unmanned aerial vehicles (UAVs)
- Solar fuels

Sub-Area 3.3 III-V Space Photovoltaic Modules, Systems, and Flight Experience
Sub-Area Chair: Tetsuya Nakamura, JAXA, Japan

This Sub-Area includes all module- and systems-level development for space applications based on III-V photovoltaic devices, as well as on-orbit reliability and performance. Key topics include:

- Integration of space solar cells onto rigid or flexible backplanes
- Stabilization against damage from UV radiation, high energy particles, electrostatic discharge, and other space hazards
- Interactions with electric propulsion subsystems
- Micro-CPV for the space environment
- Flight experience and reliability studies
- Strategies to improve AM0 calibration of solar cells and panels

Sub-Area 3.4: Alternatives to III-V for Space Applications
Sub-Area Chair: Ahmad Kirmani, Rochester Institute of Technology, USA

This Sub-Area solicits papers regarding all aspects of photovoltaic materials, structures, devices, or systems based on alternatives to III-Vs (e.g. perovskites, silicon, chalcogenides, etc.) for the space environment. Topics of interest include:

- Novel AM0 cell and module designs
- Materials design for interlayers and interfaces to enhance stability
- Environmental effects on alternative materials
- Reliability
- Testing standards

- Flight experience

Sub-Area 3.5: Photonic Power Converters

Sub-Area Chair: Oliver Höhn, Fraunhofer ISE, Germany

Sub-Area 3.5 seeks abstracts concerning all aspects of photonic energy conversion involving primary light sources other than the sun. Topics of interest include:

- Single and multijunction laser power converters
- Module- and system-level laser power beaming
- III-V devices for thermophotovoltaics (TPV)
- Ambient light harvesting
- Implantable and biomedical systems and applications

Area 4: Silicon Photovoltaic Materials and Devices

Area Chair: *Ujjwal Das, University of Delaware*
Co-Chair: *Di Yan, University of Melbourne, Australia*

Sub-Area 4.1: **Silicon materials, bulk defects, surface passivation and advanced light management**
Sub-Area 4.2: **High efficiency silicon solar cells**
Sub-Area 4.3: **Silicon as the sub-cells in tandem structure**
Sub-Area 4.4: **Metallization, Interconnection, Module Integration, Recycling/Sustainability and Novel PV Integrations**
Sub-Area 4.5: **Device Physics, Modeling, New/Enhanced Characterization Techniques**

Area Description

Silicon remains dominant in photovoltaic technology with market share exceeding 90%, while technologically continuing to develop and scientifically entering the realm of innovative integrations. Commercial cell efficiencies exceeding 24%, module costs below $0.3/W are becoming routine as manufacturers transition to TOPCon and SHJ structures. The emergence of bifacial, IBC, and shingled cells has broadened the module flavors, while new applications in BIPV, VIPV, Floating PV are expected to bring unforeseen innovation. The dawn of silicon-based tandems and multi-junctions are anticipated to yield an era of 30+% efficiencies as the new norm. This area addresses advancements in the full breadth of silicon materials, high efficiency device designs, sub-cell designs in tandem configurations, innovative integrations, materials recycling, sustainability, and new industrial trends, opportunities, challenges and roadmaps shaping the future of silicon photovoltaics.

Sub-Area 4.1: Silicon materials, bulk defects, surface passivation and advanced light management

Sub-Area Chair: Anyao Liu, The Australian National University, Australia

Sub-area 4.1 focuses on advancement in silicon wafer production, thin silicon growth methods, defect engineering, surface passivation, advanced light management, and their impact on device performance and integration. Topics include:

- Silicon purification, crystallization, doping, wafering
- Thin silicon growth methods, bulk defects and surface/interface passivation studies
- Surface engineering, light management – topics related to novel surface engineering like plasmonic, spectral shaping may be organized with Area 1

Sub-Area 4.2: Passivated, Carrier-Selective, and Heterojunction Contacts

Sub area Chair: Thien Truong, National Laboratory of the Rockies (formerly NREL), USA

Sub-area 4.2 focuses on developments in high efficiency silicon single junction solar cells via different cell technologies (PERC, TOPCon, HJ), and integration of various carrier selective passivated contacts. Specific topics are:

- Fabrication, characterization, commercialization, and device physics of passivated and carrier-selective contacts
- Contacts employing amorphous silicon, tunnel oxides, polysilicon, and other novel materials
- Bifacial, all back contact, and other advanced cell architectures with such carrier-selective contacts
- Cell-level degradation and reliability studies of passivated contact structures – topics related to module-level degradation may be organized with Area 8

Sub-Area 4.3: Silicon as a sub-cell for tandem structure

Sub area Chair: TBD

Sub-area 4.3 focuses on the fabrication and technology development of silicon sub-cells for tandem applications, including 2-, 3- and 4- terminal configurations. Topics that primarily focus on non-Si top cells may be organized with areas 1, 2, or 6. The key topics include:

- Silicon sub-cell architectures with different cell technologies, such as TOPCon, PERC, HJ or other advanced heterocontacts, including 2-, 3- and 4- terminal designs
- Light management strategies to enhance the optical performance of silicon sub-cells
- New materials integration and engineering interconnect layer between silicon and other sub cells
- Reliability of the silicon sub-cells during the other cell fabrication process
- Computational design of materials, interfaces, and device modeling of Si sub-cell for tandem application

Sub-Area 4.4: Metallization, Interconnection, Module Integration, Mass production, Recycling/Sustainability and Novel PV Integrations

Sub area Chair: Eve Krassowski, CE Cell Engineering GmbH, Germany

Sub-area 4.4 covers the electrode metallization processes and characterization, materials recycling, sustainability, and novel module construct and integration for various applications. Please note some overlap on sustainability with Area 11. Topics include:

- Electrode deposition/formation processes including evaporation, printing, plating, multiwire bonding, laser assisted process, selective doping
- Contact materials to eliminate/reduce indium and silver consumption
- Interconnection for advanced cell structures like back contact cells and Si-based tandems

- Recent achievements, challenges, related cost analysis, and roadmaps in silicon PV mass production
- Life cycle assessment, materials recycling, sustainability

Sub-Area 4.5: Device Physics, Modelling, New/Enhanced Characterization Techniques
Sub area Chair: Paul Procel Moya, TU Delft, Netherlands

Sub-area 4.5 is aimed at understanding and modeling of Si-based solar cells, including approaches describing the physics of stability and reliability, as well as new interpretations of device physics that guide the Si PV performance closer to the intrinsic limit. Topics include:

- Device physics, multi-dimensional models, computational simulations
- Strategies to approach theoretical limit of silicon single junction solar cells and/or silicon based tandem solar cells
- New characterization techniques and numerical analysis

Area 5: Characterization Methods

Area-Chair: *André Augusto, Dalarna University, Sweden*
Co-Chairs: *Ziv Hameiri, University of New South Wales, Australia*

Sub-Area 5.1: In-situ and In-Line Metrology, Data Analysis, and Machine Learning
Sub-Area 5.2: Characterization Instruments and Techniques
Sub-Area 5.3: Characterization of Photovoltaic Materials and Cells
Sub-Area 5.4: Characterization of Photovoltaic Modules and Systems

Area Description

Measurement is the backbone of research development, process optimization, process control, quality assurance, and field monitoring. This area focuses on the continuous development and adaptation of characterization techniques throughout the PV value chain. It also emphasizes the data interpretation, analysis, statistical inference, and machine learning that relate measured information to the material/device properties, process conditions, experimental guidance and other practical consequences, making them useful.

Sub-Area 5.1: In-situ and In-Line Metrology, Data Analysis, and Machine Learning

Sub-Area Chair: Mathilde Fievez, Beyond Silicon, USA

Findings related to

- In-situ monitoring (e.g. thickness determination during thin film deposition, optical emission spectroscopy)
- High sampling rate inline metrology (e.g. electroluminescence or photoluminescence imaging, wafer resistivity)
- Analysis of high-volume data combining multiple pieces of information that are relevant to PV manufacturing or field monitoring contexts - the novelty may be related to the measurement technique itself, its modification to capture data at high throughput, or new insights on high-volume data obtained by statistical analysis/model-based analysis/machine learning.

Sub-Area 5.2: Characterization Instruments and Techniques

Sub-Area Chairs: Dana Kern, National Laboratory of the Rockies (formerly NREL), USA
Liu Muqing, Yangtze Institute for Solar Technology, China

Measurement techniques that elucidate the material, functional, optical or electrical properties of PV materials and devices (cells or modules) are of interest. Reports that focus on the measurement principles, arrangement or routines and how they relate practically to PV processing and performance, are preferred. Topics may include methods based on:

- Interferometry, spectroscopy, and microscopy
- Imaging

- Electrical probing and scanning probes
- Development of operando measurements

Sub-Area 5.3: Characterization of Photovoltaic Materials and Cells
Sub-Area Chair: Shuai Nie, University of New South Wales, Australia

Findings related to the measurement, interpretation and analysis of PV materials cells. Examples of topics that would fit into this area include studies on:

- Materials - Defect states, material composition, electrons and ion transport, interface properties
- Cells - Device transients, instability and degradation in cell performance, and the impact of defects and operating conditions on cell-level electrical characteristics

Sub-Area 5.4: Characterization of Photovoltaic Modules and Systems
Sub-Area Chair: Gisele Benatto, Technical University of Denmark, Denmark

This sub-area encompasses the characterization of complete modules and systems relevant to field performance including but not limited to:

- Large area characterization - photoluminescence, electroluminescence, ultraviolet (UV) fluorescence, infrared (IR) thermography, and current-voltage traces
- Cell level characterization (directly connected to module-level characteristics) - laser beam induced current (LBIC), external quantum efficiency (EQE), angular resolved reflectance, or microscopy – note: emphasis is on studies related to module efficiency, cell-to-module losses, and module power under real operating conditions.

Studies on durability and accelerated testing should be submitted to Sub-Areas 8.1 or 8.2.

Area 6: Perovskite and Organic Materials and Solar Cells

Area-Chair: *Nicholas Rolston, Arizona State University, USA*
Co-Chairs: *Yanqi Luo, Argonne National Laboratory, USA*

Sub-Area 6.1: Advances in Materials Development
Sub-Area 6.2: Stability and Reliability of Solar Cells and Modules
Sub-Area 6.3: Advanced Perovskites and Organic Tandem/Multijunction Solar Cells
Sub-Area 6.4: Scalable Deposition Techniques and In-line Metrologies

Area Description

In the vast world of emerging materials for photovoltaic applications, halide perovskites currently lead the pack. With power conversion efficiencies exceeding 26% for single-junction devices, and 34.6% and 29% for perovskite-silicon tandems and all-perovskite tandems, respectively, these materials hold significant promise. In recent years organic solar cells have also experienced a renaissance with the advent of non-fullerene acceptors, having achieved certified efficiencies of >20%. However, in order to deliver on the abundance of promise these technologies hold, their impressive efficiencies need to be balanced with long-term operational stability and scalability. Equally important is the development of sustainable materials and processing methods to address concerns around environmental impact, toxicity, and recyclability. Area 6 provides a platform for researchers in the field to present their latest results in the area of halide perovskite and organic photovoltaic devices. Topics in this area will range from materials development and advances in sustainable and scalable deposition techniques, and large area processing, to multijunction devices and the stability and reliability of lab scale devices and modules.

Sub-Area 6.1: Advances in Material Development and Sustainability

Sub-Area Chair: Min-cheol Kim, Pusan National University

Sub-area 6.1 focuses on advances in material development for perovskite and organic photovoltaics and strategies that enhance sustainability across the material lifecycle. This includes:

- Interface passivation
- New transport and interlayer materials
- Compositional and additive engineering
- New concepts for sustainable materials, processes and recycling approaches

Sub-Area 6.2: Stability and Reliability Solar Cells and Modules

Sub-Area Chair: Sona Ulicna, EPFL, Switzerland

Sub-area 6.2 focuses on developments critical to commercializing emerging PV technologies-operational stability. Topics include:

- Outdoor testing

- Accelerated and combined stress testing
- Ion migration
- Post-mortem failure analysis
- Packaging and module design

Sub-Area 6.3: Advanced Perovskites and Organic Tandem/Multijunction Solar Cells
Sub-Area Chair: Mathilde Fievez, Beyond Silicon, USA

Sub-area 6.3 focuses on approaches to delivering high-performance tandem architectures with 2, 3, or 4-terminals containing one or more perovskite/organic layers. This includes (but is not limited to):

- Perovskite/Si tandems
- All-perovskite tandems
- Perovskite/Organic tandems
- Perovskite/CIGS tandems

Sub-Area 6.4: Scalable Deposition Techniques and In-line Metrologies
Sub-Area Chair: Qi Li, First Solar, USA

Sub-area 6.4 focuses on scalable techniques for the large-area coating of halide perovskites and organic semiconductors, as well as the development and use of in-line metrology used for the characterization of the same. Topics include:

- Slot-die coating
- Vapor deposition
- Ink engineering and crystallization
- In-line and *in situ* characterization techniques to identify defects and phase segregation

Area 7: PV Modules, Manufacturing, Systems and Applications

Area Chair: *Chiara Barretta, Polymer Competence Center Leoben GmbH, Austria*
Co-Chairs: *Marios Theristis, Sandia National Laboratories, USA*

Sub-Area 7.1: New Materials and Production Technologies
Sub-Area 7.2: New Applications for PV
Sub-Area 7.3: System Design Optimization, Power Electronics, and Batteries
Sub-Area 7.4: PV Performance Modeling and Assessment

Area Description

This area focuses on the latest developments in PV module manufacturing and production, including new materials, processes, and strategies that improve efficiency, reliability, and circularity. It also highlights novel applications and integration concepts, such as building-integrated and applied PV, agrivoltaics, floating PV, and other emerging deployment models. On the system side, contributions are invited on design and optimization approaches, with particular interest in integrated power electronics and energy storage solutions that strengthen flexibility and resilience. The scope further includes advances in energy yield prediction and performance modeling, with emphasis on reproducibility, interoperability and validation.

Sub-Area 7.1: New Materials and Production Technologies

Sub-Area Chair: Stefan Mitterhofer, National Institute of Standards and Technology (NIST), USA

In Sub-Area 7.1, abstracts are invited for innovations in module construction that have been largely responsible for significant increases in efficiency, annual yield, and the corresponding decreases in the levelized cost of energy (LCOE) for photovoltaic electricity generation. Please note possible overlaps with Area 6. Topics include:

- New materials for backsheets, encapsulants, frontsheets, or interconnects
- New techniques for module assembly to reduce cost, increase efficiency, enhance reliability and/or circularity
- New designs for bifacial applications
- Module adjustments and optimization for extreme environments
- Novel module electrical configurations

Sub-Area 7.2: New Applications for PV

Sub-Area Chair: Sara Bouguerra, Hasselt University, Belgium

Sub-Area 7.2 welcomes abstracts on new and emerging applications of PV, particularly those that highlight multifunctional uses and expand the role of PV devices. These include:

- New applications for PV including but not limited to agrivoltaics, building integrated and PV, floating PV, and non-traditional applications

- Recent advances in building integrated or applied PV systems (BIPV or BAPV), off-grid PV systems, hybrid systems, mini/micro-grids, DC end-use systems, mobility and transportations systems, infrastructure-integrated PV, agrivoltaics, floating solar, “wearable” PV, and other non-traditional PV applications

Sub-Area 7.3: System Design Optimization, Power Electronics, and Batteries
Sub-Area Chair: Brian Mirletz, National Laboratory of the Rockies (formerly NREL, USA

Sub-Area 7.3 includes a broad range of topics that includes new concepts for complete photovoltaic systems, methods of system optimization, field results, full life-cycle analysis of system components, in addition to power converters and energy storage technologies. Topics include:

- System design and optimization (e.g., PV + BESS sizing)
- Inclusion of power electronics, and energy storage solutions that enhance the performance and grid integration of PV systems
- Grid-tied and off-grid system designs, power converter technologies, maximum power point tracking, and energy storage integration
- Improving system efficiency, reliability, and grid stability, contributing to the overall growth and sustainability of solar energy systems

Sub-Area 7.4: PV Performance Modeling and Assessment
Sub-Area Chair: Kevin Anderson, Sandia National Laboratories, USA

Sub-Area 7.4 focuses on PV performance modeling for both design-stage predictions and operational expected yield. Abstracts relating to mechanical, thermal, and electrical modelling of PV modules and systems including methods for determining parameters for these models are also welcome. Emphasis is placed on reproducibility, interoperability and validation. This covers the following topics:

- Modeling and predicting the energy yield of PV systems
- Meteorological data integration, climate-specific models, and uncertainty analysis
- Developing reliable methods to assess and analyze PV system performance (e.g., capacity tests, O&M/asset management, analytics)
- Model and software validation and benchmarking

Area 8: Module and System Reliability

Area Chair: Kristopher O. Davis, University of Central Florida, USA
Co-Chair: Ana Dyreson, Michigan Technological University, USA

Sub-Area 8.1: Accelerated Testing of PV Materials, Modules, and System Components
Sub-Area 8.2: PV Reliability and Durability Observations from the Field
Sub-Area 8.3: Data-Centric Approaches to Promote PV Module and System Reliability
Sub-Area 8.4: Design and Operation for PV System Reliability in Extreme Climates

Area Description

The long-term performance, reliability, and durability of PV modules and systems are all critical to the continued growth of the PV sector. PV modules and systems are often deployed in harsh weather conditions, and the expected lifetimes are extending to 30-40 years. The industry is both risk averse, requiring all new technologies across the supply chain to prove their robustness in extensive testing before field deployment, and rapidly adopting new technologies faster than they can be field-tested. Area 8 takes a holistic approach considering the performance, reliability, and durability of all types of PV systems and the constituent components (e.g., modules, power electronics, energy storage, and other balance of system components) and materials that make up these components. Topics in this area will cover accelerated testing, testing and observations from the field, and measurement and analysis methods that support reliability and durability research. Reliability and durability studies of both mature and emerging types of PV modules and system components will be covered in this area.

Sub-Area 8.1: Accelerated Testing of PV Materials, Modules, and System Components

Sub-Area Chair: Archana Sinha, Kiwa PVEL, USA

PV modules and system components are exposed to a wide range of stresses, such as high temperatures, temperature fluctuations, humidity, ultraviolet light, electrical bias, and various mechanical stresses. Submissions in Sub-Area 8.1 should explore the development, validation, and implementation of accelerated testing as a means of enhancing PV module and system reliability and durability. Submissions covering the following topics are encouraged:

- Accelerated testing methods for PV materials, modules, and system components and findings from these tests
- Validation of accelerated testing approaches using field-based results
- Modeling, simulation, measurement, and analysis methods that support accelerated testing research
- Accelerated testing studies that provide insights into degradation mechanisms and failure modes, linking them to specific external stressors
- Results from both well-established technologies and commercially relevant emerging technologies, including c-Si, CdTe, perovskites, and tandem modules

Sub-Area 8.2: PV Reliability and Durability Observations from the Field
Sub-Area Chair: Maulib Kivambe, Qatar Environment and Energy Research Institute, Qatar

Observations from the field are invaluable in efforts to improve the reliability and durability of PV systems and the materials, modules, and other components that make up these systems. Sub-Area 8.2 focuses on these observations, as well as the tools and methods needed to more effectively study the performance, reliability, and durability of PV systems operating in the field. Submissions covering the following topics are encouraged:

- Observations and reports related to the performance, reliability, and durability of PV systems operating in the field, including findings related to the materials, modules, and other components that make up these systems
- Modeling, simulation, measurement, and analysis methods that support field testing and performance monitoring
- Studies demonstrating effective solutions and corrective actions for maximizing energy when confronted with performance, reliability, and durability issues in the field
- Field observations and reports proving insights into degradation mechanisms and failure modes, linking them to specific design choices, materials, and manufacturing processes
- Results from both well-established technologies and commercially relevant emerging technologies, including c-Si, CdTe, perovskites, and tandem modules

Sub-Area 8.3: Data-Centric Approaches to Promote PV Module and System Reliability
Sub-Area Chair: Gisele Alves dos Reis Benatto, Technical University of Denmark, Denmark

With the rapid development and adoption of new materials and technological innovations currently occurring across the entire PV sector, the industry and R&D community will need to be vigilant in efforts to ensure reliability and durability are not compromised. Sub-Area 8.3 will cover the sharing of data, knowledge, and analytical tools could help in these efforts, as well as the application of AI tools to promote PV module and system reliability/durability. Submissions covering the following topics are encouraged:

- Open datasets related to PV module and system reliability and durability
- Frameworks to curate data, knowledge, and information related to PV module and system reliability and durability
- Open-source modeling and analysis tools related to PV module and system reliability and durability
- Initiatives to promote the sharing of data, code, and knowledge related to PV module and system reliability and durability

Sub-Area 8.4: Design and Operation for PV System Reliability in Extreme Climates

Sub-Area Chair: Laurie Burnham, Sandia National Laboratory, USA

The continued global expansion of PV into more diverse climate zones as well as the increase in extreme weather events are generating a need for more durable system design and operational strategies for extreme weather. Extreme weather events including heavy snowfall, hurricanes, hail, and high wind events can reduce energy generated and/or cause long term damage if not anticipated in design. In some cases, operational decisions can reduce damage. Sub-Area 8.4 will cover novel design and operation approaches for increasing PV durability from the module to the system scale. Please note some overlap of this Sub-Area with Area 7. Submissions on the following topics are encouraged:

- Proposals for more durable system designs supported by modeling including computational fluid dynamics, finite element analysis, and other analytical approaches
- Observations from field testing of novel system designs and operational approaches in extreme climates
- Monitoring approaches including structural damage and imaging to increase situational awareness for extreme weather
- Novel tracker technologies (e.g., designs, control) compatible with extreme weather conditions

Area 9: Power Electronics and Grid Integration

Area Chair: *Fabio Andrade, University of Puerto Rico, Mayaguez. Puerto Rico*
Co-Chair: *Jesus David Vasquez, Oak Ridge National Laboratory, USA*

Sub-Area 9.1: Power Converter Design, Modelling, Reliability, and Control
Sub-Area 9.2: Ancillary Services and Grid Support Functionalities
Sub-Area 9.3: Microgrids and Distribution System Operation and Control

Area Description

As photovoltaic (PV) installations become increasingly widespread, the demand for power electronic converters designed to interconnect solar panels to the grid will continue to rise. Moreover, the rapid integration of massive levels of distributed PV penetration poses new challenges for managing grid operations. At the component level, advanced inverter functionality and energy storage will enhance grid stability by enabling rapid response to control and stabilize the grid during rapidly changing phenomena. Furthermore, the development of advanced topologies and controls will further improve converter performance and reduce system costs. At the system level, optimization and management of distributed PV and other grid resources will continue to support the integration of large amounts of renewable energy and enable more advanced grid services and support functions. The evolving nature of power distribution systems will motivate new methods for microgrid and distribution grid operations, requiring proactive management of variable generation resources. Therefore, the power electronics and power systems community is encouraged to submit contributions that address the full range of scientific and technical aspects related to PV grid integration.

Sub-Area 9.1: Power Converter Design, Modelling, Reliability, and Control

Sub-Area Chair: Daniel Campo, University of Puerto Rico, Aguadilla. Puerto Rico

Sub-Area 9.1 focuses on new converter designs and control for DC-DC and inverter-based applications for PV power. Additionally, contributions related to modeling and reliability analysis of power grids with high penetration of inverter-based PV power are welcome. Topics include:

- Design, modelling and control of power electronics for PV converters
- Novel circuit designs, magnetics, wide bandgap semiconductor materials, and other innovative approaches to component-level converter design
- Advanced power electronics control at the level of individual converters, multiconverter-based microgrids, power systems, and large-scale PV power plants
- The reliability of power converters and the impact of PV converters on the reliability of power grids

Sub-Area 9.2: Ancillary Services and Grid Support Functionalities

Sub-Area Chair: Medhi Savaghebi, DTU, Denmark

Sub-Area 9.2 focuses on advanced control functionalities performed by inverter-based PV power systems, providing ancillary services to support power grid operation. Topics include:

- Synthetic (virtual) inertia
- Voltage and frequency regulation.
- Reactive power provision
- Fault current provision to maintain power system protection
- Ramp rate limiting, or power smoothing to prevent frequency events
- Harmonic mitigation, and operation of PV converters as active power filters to improve power quality
- Ancillary services provided by PV converters in microgrid environments

Sub-Area 9.3: Microgrids and Distribution System Operation and Control

Sub-Area Chair: Nelson Diaz, Universidad Distrital F.J.C, Bogotá, Colombia

Sub-Area 9.3 focuses on highlighting the challenges and successful applications of integrating PV power units into microgrids. Topics include:

- Impact of systems that include significant amount of PV converters on the reliability of power grids.
- Challenges of integrating PV into microgrids and distribution systems.
- PV sizing and placement, dispatching, and other pertinent issues for the operation in microgrids based on PV converters
- Coordinated operation and management of microgrids based on PV converters

Area 10: Solar Energy Meteorology

Area Chair: *Dazhi Yang, Harbin Institute of Technology, China*
Co-Chairs: *Martin János Mayer, Budapest University of Technology and Economics, Hungary*

Sub-Area 10.1: Solar Irradiance Measurement, Modeling, and Resourcing
Sub-Area 10.2: Solar Irradiance and PV Power Forecasting
Sub-Area 10.3: Solar Variability Management and Firm Power Delivery

Area Description

Solar energy meteorology is primarily concerned with resource assessment and forecasting. Whereas the former deals with the long-term (years to decades) behavior of irradiance, the latter addresses the prediction of short-term (seconds to months) availability of irradiance, and both are essential to PV system operation and management. An additional topic is solar variability management with dispatchability enablers, such as energy storage, geographical smoothing, or PV overbuilding & proactive curtailment, which are relevant in both solar resourcing and forecasting. This research area covers techniques and methods to measure, model, and forecast irradiance with a special focus on variability mitigation strategies.

Sub-Area 10.1: Solar Irradiance Measurement, Modeling, and Resourcing
Sub-Area Chair: TBD

Accurately measuring and modeling the available solar resource is essential for technical and economic planning of PV systems and for evaluating the performance of existing systems. This sub-area covers topics related to reducing the uncertainties in PV performance modeling and monitoring, including:

- Radiometer design (thermal offsets, spectral measurements, etc.)
- Radiation models (clear sky models, decomposition, transposition, etc.)
- Solar resource assessment methodologies (satellite models, re-analysis models, etc.)
- Variability and uncertainty quantifications
- Measurements for bifacial systems (rear-side irradiance and albedo)
- Ancillary measurements such as soiling, temperature, precipitation, and snow

Sub-Area 10.2: Solar Irradiance and PV Power Forecasting
Sub-Area Chair: TBD

As PV generation increases, the role of solar irradiance and PV power forecasting becomes ever more important to successfully integrate renewable energy into the grid. This sub-area covers the latest improvements in forecast modeling at various time and spatial scales, including:

- Physical methods for solar forecasting (i.e., NWP, satellite, and sky camera)

- Irradiance-to-power conversion via model chains
- Probabilistic and ensemble forecasting
- Regional forecasting and upscaling
- Machine- and deep-learning-based forecasting and post-processing
- Forecast verification

Sub-Area 10.3: Solar Variability Management and Firm Power Delivery
Sub-Area Chair: TBD

Solar irradiance and thus PV power are variable in nature; unlike conventional generators, PV power is non-dispatchable. To mitigate this inherent variability, firm power enablers, such as batteries, solar–wind generation blending, or demand response, are widely employed in theory and practice. This subarea covers new ideas and new studies on enhancing dispatchability of variable PV power.

- Solar variability quantification
- Predictability of solar power
- Battery–PV systems
- Firm generation with multi-storage (i.e., battery, pumped hydro, hydrogen, fuel cell, or implicit storage)
- Firm forecasting
- Optimization model for dispatchable/flexible PV
- Effect of firm power delivery on power system operations (e.g., day-ahead scheduling)

Area 11: PV Deployment, Policy and Sustainability

Area Chair: *Arnulf Jäger-Waldau, EC-JRC, Italy*
Co-Chairs: *Rachel Woods-Robinson, University of Washington, USA*

Sub-Area 11.1: Economics, Policy, and Energy Justice
Sub Area 11.2: Environmental Sustainability
Sub Area 11.3: User Behavior, Education in Institutes of Learning, and Workforce Development
Sub Area 11.4: The Role of Photovoltaics in the Transition to a 100% Renewable Energy Supply

Area Description

The PV Deployment, Policy and Sustainability area provides an opportunity to discuss aspects required to ensure the long-term success of the PV industry. This includes discussions on four themes focusing on 1) economics, policy, and energy justice, 2) environmental sustainability, 3) social interventions, and 4) the interplay of these topics toward 100% renewable energy generation. Recognizing the importance of student engagement for sustained growth in the industry, we encourage students to submit papers focusing on outreach and education efforts in educational institutes.

Sub-Area 11.1: Economics, Policy, and Energy Justice

Sub-Area Chair: Anna Bruce, UNSW, Australia

This sub-area focuses on the economics and policy developments critical to expanding PV deployment and/or energy justice including:

- Overcoming barriers in PV deployment and providing equitable and affordable access to solar energy
- Policy impacts, market drivers, and financial considerations
- Unique case studies of interest to conference participants also welcomed

Sub Area 11.2: Environmental Sustainability

Sub-Area Chair: Oksana Makarova, Harvard University, USA

This sub-area seeks submissions with a broad, systems-level perspective on the sustainability of PV throughout the life cycle. Topics of interest include:

- Discussions on current and future PV technologies through lifecycle assessment, material supply, manufacturing, and end-of-life management
- Results from simulations, surveys, and focus group discussions on these topics are welcomed

Sub Area 11.3: User Behavior, Education in Institutes of Learning, and Workforce Development

Sub-Area Chair: TBD

This sub-area focuses on increasing solar PV adoption through understanding user behavior and developing a skilled workforce for the solar PV industry. These areas of research focus on early engagement of students and workforce development. Existing results are highly encouraged for abstract submission and topics of interest include studies on:

- Influencing user behavior
- Encouraging adoption
- Early engagement of students at all levels (e.g., high school, vocational training, technical school and university)
- Innovative solar education and workforce development

Sub Area 11.4: The Role of Photovoltaics in the Transition to a 100% Renewable Energy Supply

Sub-Area Chair: Jan Christoph Goldschmidt, Universität Marburg, Germany

It took 68 years to install the first 1 TW of solar photovoltaic systems, but only 2 years to build the next 1 TW. Soon, we will see 1 TW and more installed annually. This has a significant impact not only for the electricity system, but for our global energy supply heading towards being dominated by renewables and especially cheap PV electricity. We especially encourage contributions from students and aim to cover diverse regions and approaches. Topics of interest for this session are:

- The role of photovoltaics on the transition towards 100% renewable energy on national, regional or global scale
- Challenges of this transitions, and technologies and concepts to address them

We are hoping to have a Joint Session with area 8, 9, 10 and 11 on “How to guarantee a stable grid operation during a 100% solar share”

Area 12 Special Sessions: Industrial Perspective

Area Chair: *Radovan Kopecek, ISC Konstanz, Germany*
Co-Chairs: *Mathide Fievez, Beyond Silicon, United States*

Sub-Area 12.1: Manufacturing Innovations and Technology Transfer
Sub-Area 12.2: Testing, Standards, and Protocols
Sub-Area 12.3: Start-Ups and New Business Models

Area Description
This area highlights the industrial perspective on PV innovation, focusing on how technologies transition from laboratory demonstrations to scalable, bankable products. Topics include novel materials and processes for high-volume manufacturing, technology transfer pathways from R&D institutes to industry, new tools and protocols for accelerated and outdoor testing, and the dynamic landscape of PV start-ups. The goal is to bridge research and industry by sharing best practices, challenges, and opportunities for commercialization and deployment.

Sessions in this area will be held as Special Sessions, at distinct times from the regular oral sessions. Abstracts are welcome, and the special session panelists will be a combination of invited speakers and abstract submissions.

Sub-Area 12.1: Manufacturing Innovations and Technology Transfer
Sub-Area Chair: Joris Libal, ISC Konstanz, Germany

This sub-area will address how novel processes and materials are being scaled from research prototypes to industrial production, with emphasis on compatibility with high-volume manufacturing and retrofitting of existing lines. Contributions are welcome from R&D institutes and universities, equipment suppliers, and manufacturing companies. Topics include:

- Innovative processes and machines
- Innovative materials (enabling reliability and high throughput)
- R&D scale-up: lessons learned on scaling losses, line yield, and process optimization.
- Technology transfer
- Techno-economic assessment of innovative processes

Sub-Area 12.2: Testing, Standards, and Protocols
Sub-Area Chair: Peter Pasmans, Wavelabs/Eternal Sun

As new PV technologies reach industrial readiness, reliable testing and standards become critical. This sub-area covers recent progress in accelerated indoor testing tools, outdoor performance monitoring, and ongoing international standards development. Topics include AI-driven production monitoring, smart factories, and innovative testing methods for emerging solar technologies like perovskite and tandem modules. Topics include:

- Indoor accelerated testing

- Outdoor testing platforms
- Standardization and IEC updates for emerging technologies
- Testing protocols for bifacial, tandem, and other emerging PV products.
- Roundtable discussion: *“Standards for Perovskite and Emerging PV Products”*.

Sub-Area 12.3: Start-Ups and New Business Models
Sub-Area Chair: Peter Fath, RCT Future

Start-ups are increasingly driving innovation in PV materials, processes, and system integration. This sub-area focuses on emerging companies, their technological roadmaps, and the challenges of scaling from lab to market. Ideas about “outside-of-the-box” PV business cases are welcome.