CALL FOR PAPERS

THE 48th IEEE PHOTOVOLTAIC SPECIALISTS CONFERENCE

June 20-25, 2021
Diplomat Beach Resort
Miami-Ft. Lauderdale, Florida, USA

Abstract deadline: January 25, 2021

On behalf of the Technical Program Committee, I am honored to invite you to submit an abstract on your latest achievements in photovoltaic (PV) research, development, applications, and impact to the 48th IEEE Photovoltaic Specialists Conference (PVSC-48). The PVSC-48 endeavors to cover the full spectrum of PV knowledge and innovation, from the basic science and engineering of materials, devices, and systems, to the examination of policy and markets and critical issues of social impact. PVSC aims to be a highly interactive and inclusive venue for everyone, from seasoned PV experts to entry-level professionals to students alike, providing a unique opportunity to meet, share, and discuss PV-related developments in a timely and influential forum. Please contribute to the PVSC's tradition as the premier international conference on PV science and technology and help usher in a solar-powered world!

PVSC-48 brings back the traditional 12 Technical Areas, along with a slate of compelling Keynote and Plenary Speakers. Delivering our Keynote address will be Professor Yi Cui from Stanford University, presenting on "Metal-H_2 Batteries for Large Scale Stationary Energy Storage." Plenary Speakers thus far include Laura Miranda (Oxford PV), Joe Berry (NREL), Anna Fontcuberta i Morral (EPFL), Marika Edoff (Uppsala University), and Xiaoting Wang (Bloomberg New Energy Finance). The conference will also host several exciting cross-cutting themes and joint areas, including "Advanced Resource Management for 100% Renewable Electricity" and "Hybrid Tandem/Multijunction Solar Cells," with additional topically relevant sessions and events in the works. We also place a particular focus on issues of equity and social justice within the PV field and in its use and impact around the world. When submitting an abstract in response to such topics please either select the specific Joint Area noted within the Area Descriptions (if applicable) or the Technical Area that best fits the nature of the work.

To have your paper considered for presentation at the PVSC-48, please submit:

1. An evaluation abstract (3 pages maximum for technical committee review);
2. A short abstract of 300 words or less for display on the PVSC-48 website.

Abstract submission is via the PVSC-48 website at http://www.ieee-pvsc.org. Evaluation abstracts are expected to be detailed enough to allow a thorough technical review. Templates are provided at the conference website for your (and our) convenience. **The deadline for abstract submission is January 25th, 2021** at midnight Pacific Standard Time (UTC - 8 hours). Contributing authors will be notified of the acceptance status of their papers on or around March 14th, 2021, after which they will need to confirm their ability to present at the conference. For visa applications, an invitation letter can be issued any time after you register for the conference.

Following with PVSC tradition, publication of a conference proceeding is mandatory. For the sake of convenience, evaluation abstracts will automatically be used as the paper of record, which authors will have the option of replacing with a dedicated manuscript by the May 23rd, 2021 publication deadline.

Finally, we note that the IEEE PVSC understands that the current global pandemic might have various enduring effects on face-to-face meetings. We certainly hope to see you in Miami-Fort Lauderdale, but rest assured that we will continue to comply with strict COVID-19 guidelines in 2021. All options will be considered to provide all our attendees with the safest and most productive meeting environment/format. Please submit your abstract for review by the deadline and we will be in touch with authors on a timely basis as we determine the best path forward.

So once again, on behalf of the Technical Program Committee, I look forward to welcoming and meeting with you next year at the 48th IEEE Photovoltaic Specialists Conference!

Tyler J Grassman
Technical Program Chair
2021 IEEE Photovoltaic Specialists Conference (PVSC-48)

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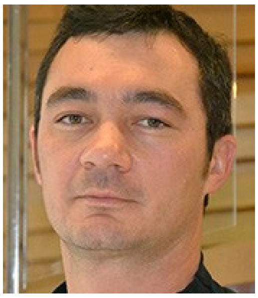
National Renewable Energy Lab
USA



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USA

Area 1: Fundamentals and New Concepts for Future Technologies

Area Chair: Adele Tamboli, National Renewable Energy Laboratory, USA
Co-Chairs: Elisa Antolin, Universidad Politécnica de Madrid, Spain
Yoshitaro Nose, Kyoto University, Japan

Sub-Area 1.1: Fundamental Conversion Mechanisms
Sub-Area 1.2: Unconventional Contact and Absorber Materials; Novel Deposition Techniques
Sub-Area 1.3: Unconventional Material & Device Architectures
Sub-Area 1.4: 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, in addition to 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, nanostructures, novel multijunction architectures, advanced optical management approaches, new materials and synthesis processes, and unconventional conversion mechanisms.

Note that Area 1 (along with Area 12) will also be participating in a pilot double-blind review program for submitted abstracts. Special submission instructions will be provided on the abstract preparation/author information page as the submission deadline approaches.

Sub-Area 1.1: Fundamental Conversion Mechanisms

Sub-Area Chair(s): Matt Sheldon, Texas A&M University, USA

Sub-Area 1.1 captures both experimental and theoretical work exploring new paradigms for solar energy conversion. Papers submitted to this Sub-area would explore the fundamental physics or present initial experimental demonstrations related to novel energy conversion mechanisms. Papers on modeling and simulation of new device architectures to enable these conversion mechanisms are also encouraged. Areas of interest include, but are not limited to, non-conventional PV conversion processes based on quantum confined or nanostructured systems, engineered band alignments, intermediate band concepts, multiple exciton generation (MEG), thermophotonics, thermophotovoltaics, or hot-carrier effects. Also of interest are concepts and demonstrations of new materials and material science related to these concepts. Finally, crosscutting scientific approaches involving novel physics, photovoltaics for solar fuel generation, alternative solar energy storage mechanisms, and innovative device structures, are solicited.

Sub-Area 1.2: Unconventional Contact and Absorber Materials; Novel Deposition Techniques

Sub-Area Chair(s): Monica Morales-Masis, University of Twente, Netherlands

Sub-Area 1.2 covers progress on the development of novel contact and absorber materials as well as processing techniques for improving the performance, functionality, reliability, and scalability of PV devices. Topics of interest include new materials for PV, including Earth-abundant absorber materials, new contact materials including carrier selective contacts, p-type transparent conducting materials, and transparent conducting oxides. Design and selection of new materials can enable applications in single crystalline, thin film, multijunction, and nanostructured PV devices, or may enable an entirely new device class on their own. Papers are sought that describe theoretical and/or experimental development of perovskite-inspired materials as well, including but not limited to absorber layers, coatings, electrode and carrier transport materials, and transparent conductive materials. Machine learning driven materials discovery and development work is also of interest. Advances in growth, synthesis, thin film deposition, doping and passivation schemes are also solicited. Also of interest are innovative strategies to reduce the cost of more established technologies, such as novel substrates and re-use processes. Ultimately, such advances may enable cleaner and more sustainable PV deployment.

Sub-Area 1.3: Unconventional Material & Device Architectures

Sub-Area Chair(s): Qing Shen, The University of Electro-Communications, Japan

Modifications to the geometry of materials and devices can be used to realize advances in performance as well as relax material quality constraints. Sub-area 1.3 covers new material or device geometries, from nanostructured and quantum dot materials to three-terminal tandems. These unconventional architectures have the potential to improve the performance of known PV materials or to supplant them entirely. Submissions including novel designs, new material morphologies such as nanostructures, implementation of new uses of quantum confinement, and the exploitation of varying dimensionality of confinement are encouraged. Materials and multilayers that form in 2D or layered structures are of particular interest. Novel device geometries such as transistor-like or three-terminal structures are also of interest, including device design and simulation. Ideal submissions will range from studies of fundamental properties and materials to examples of working devices.

Sub-Area 1.4: Advanced Light Management and Spectral Shaping

Sub-Area Chair(s): Vivian Ferry, University of Minnesota, USA

In order to achieve high power conversion efficiency, a solar cell must effectively utilize most of the incoming photons. This process involves the efficient coupling of the incident light into the solar cell with minimum loss, and effective use of the energy imparted by each photon. This Sub-area will focus on novel concepts, including advanced anti-reflection coatings, spectrum splitting, textured light trapping surfaces (front and/or rear surface), luminescent (fluorescent)/ micro-/nano-scale concentrator systems, and advanced photonic and plasmonic structures. With respect to plasmonics, both light trapping and hot carrier effects will be considered. It will also include photon recycling and angular restriction techniques for achieving improved open circuit voltages. In addition, ways to modify the spectrum of the incident sunlight using techniques such as up or down conversion either in planar layers or in waveguide structures will be considered. Papers submitted to this Sub-area should address one or more of these themes and may be theoretical or experimental in nature.

Area 2: Chalcogenide Thin Film Solar Cells

Area Chair: Nicolas Barreau, Institut des Matériaux Jean Rouxel, U. of Nantes, France
Co-Chairs: Takeaki Sakurai, University of Tsukuba, Japan
Mirjam Theelen, TNO Solliance, The Netherlands

Sub-Area 2.1: Absorber Preparation and Material Properties
Sub-Area 2.2: Contacts, Windows, Buffers, Substrates and Superstrates, Monolithic Integration, and Interfaces
Sub-Area 2.3: Cell and Module Characterization, Analysis, Theory, and Modelling
Sub-Area 2.4: Progress in Manufacturing and Deployment
Sub-Area 2.5/3.3/4.3/6.8: Hybrid Tandem/Multijunction Solar Cells (Joint Area)

Area Description

In recent years, thin film chalcogenide solar cells based on CIGSe and CdTe have achieved remarkable progress in terms of record conversion efficiencies >22% and manufacturing at the multi gigawatts-per-year scale. Over 20 GW of thin film modules are currently installed and operating reliably in the field, helping to bring the cost of PV electricity below most other sources. These exciting developments have been enabled by decades of work by the worldwide community of dedicated research, development, and manufacturing professionals working on their science and technology.

Area 2 brings this community together yearly to present and discuss contributions on solar cells based on $Cu(In,Ga)(S,Se)_2$, CdTe, $Cu_2ZnSn(S,Se)_4$, and other related materials. The aims of Area 2 are to provide a platform for presenting recent and on-going research leading to improved understanding of materials and devices, exploring new directions for more efficient production, and narrowing the gap between champion cell and module efficiencies. Topics range from insights into basic materials science, to analysis of device properties and new device structures, to discussions of the progress in deposition methods and growth control, and to long-term performance and reliability. We look forward to an exciting, cutting-edge conference that helps advance the science and technology of these fascinating and technologically important solar cells.

Sub-Area 2.1: Absorber Preparation and Material Properties

Sub-Area Chair(s): Charlotte Platzer-Björkman, Uppsala University, Sweden
Amit H. Munshi, Colorado State University, USA

Sub-area 2.1 addresses progress in understanding thin film formation and the influence of processing on basic material properties and device performance. Examples of relevant topics include both experimental and theoretical aspects of: morphology, phase coexistence, microstructure, extended and point/bulk defects and their characterization, optoelectronic and transport properties, influence of substrates, compositional gradients and homogeneity, effects of material purity and contaminants, interrelation of properties and cell and module fabrication processes, in-situ, ex-situ and in-line methods of characterization, and impacts on short- and long-term performance.

Sub-Area 2.2: Contacts, Windows, Buffers, Substrates and Superstrates, Monolithic Integration, and Interfaces

Sub-Area Chair(s): Thomas Lepetit, University of Nantes, France
Shubhra Bansal, University of Nevada Las Vegas, USA
Raquel Caballero, Universidad Autónoma de Madrid, Spain

The processing and properties of all layers in the thin film device stack as well as their integration into monolithically-integrated modules ultimately determine the cell and module performance. Sub-area 2.2 focuses on the functions, effects and properties of substrates/superstrates, contacts, buffer and window layers, and interfaces. Submissions describing advances in understanding these aspects and their effects on short-and long-term performance are welcome. Papers on progress in the cross-cutting areas of transparent conductors, moisture barriers, new or improved substrates, established and novel methods of cell scribing and interconnection in modules, and novel topics not listed are also encouraged.

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

Sub-Area Chair(s): *Pawel Zabierowski, Warsaw University of Technology, Poland*
Thomas Paul Weiss, University of Luxembourg, Luxembourg

Continued progress in chalcogenide photovoltaics relies on continuing to gain insight into the origins of efficiency loss and concepts for overcoming them. Whereas Sub-areas 2.1 and 2.2 focus on the physical properties and processing of the layers making up cells and modules, Sub-area 2.3 addresses their net effects at the device and module level through measurement, analysis, theory, and modelling. These aspects enable feedback to continue improving cells and modules. Contributions are solicited in the areas of novel and established characterization methods, device analysis that yields insight into internal operation, one-, two- and three-dimensional modelling to understand current devices and guide progress, characterization of defects and recombination, and novel related topics not listed.

Sub-Area 2.4: Progress in Manufacturing and Deployment

Sub-Area Chair(s): *Matthew Reese, National Renewable Energy Laboratory, USA*
Veronique Gevaerts, TNO Solliance, The Netherlands

The field of chalcogenide thin film photovoltaics is rapidly transitioning from a focus solely on R&D into large-scale manufacturing and deployment. Sub-area 2.4 solicits contributions addressing module and device design, manufacturing and field deployment. Contributors from industry are encouraged to share their experience in areas focused on novel manufacturing and improvements to devices from design to long-term performance.

Sub-Area 2.5/3.3/4.3/6.8: Hybrid Tandem/Multijunction Solar Cells (Joint Area)

Sub-Area Chair(s): *Stephanie Essig, ZSW, Germany*
The Duong, Australian National University, Australia
Steve Albrecht, Helmholtz Zentrum Berlin, Germany

This wide-reaching Sub-Area solicits papers regarding materials, structures, and devices based on combinations of different materials (III-Vs, silicon, chalcogenides, organics, perovskites, etc.) toward the production and characterization of “hybrid” multi-junction solar cells. The full range of integration methodologies are of interest, including but not limited to monolithic epitaxy and deposition, wafer/layer bonding, and mechanical stacking, as well as the characterization of these materials, structures, and devices, from the atomic scale to the device level (and beyond), as related to their hybrid nature. Abstracts on the theory and modeling of such devices are welcome, as is work related to new module and system architectures optimized for such hybrid cells. This is a Joint Sub-Area between Areas 2, 3, 4, and 6, and will host the popular “Battle Royal Session” of previous years.

Area 3: High-Efficiency, Multijunction, and Concentrator Technologies

Area Chair: Stephanie Tomasulo, U.S. Naval Research Laboratory, USA
Co-Chairs: Rebecca Saive, University of Twente, Netherlands
Taizo Masuda, Toyota Motor Corp, Japan

Sub-Area 3.1: III-V Single and Multijunction Solar Cells
Sub-Area 3.2: Low-Cost, High-Performance III-V Solar Cells
Sub-Area 2.5/3.3/4.3/6.8: Hybrid Tandem/Multijunction Solar Cells (Joint Area)
Sub-Area 3.4: Applications for High Efficiency Solar Cells, including CPV

Area Description

III-V multi-junction solar cells, at least within the last few decades, have been the basis for high-performance terrestrial concentrator photovoltaic (CPV) technologies. However, the multi-junction architecture is also the only proven approach for providing efficiencies beyond the single-junction detailed-balance limit. Area 3 addresses conventional III-V solar cells and CPV technologies as well as other high-efficiency devices such as tandems with Silicon. The area specifically encourages papers that are dealing with the challenge of reducing the production cost and manufacturability of such high performance solar cells to enable competitiveness with the state-of-the-art.

Sub-Area 3.1 focuses specifically on the research and development of "traditional" III-V based single- and multi-junction devices. Given the relatively high costs of III-V materials and devices at present, Sub-Area 3.2 covers developments of low-cost approaches for III-V photovoltaics related to epitaxy, novel fabrication processes or alternate substrate growth. Sub-Area 3.3 encompasses a broader scope regarding the development of "hybrid" tandem solar cells, wherein devices are made up of multiple classes of photovoltaic materials, often including Silicon as the bottom junction. Finally, Sub-Area 3.4 integrates the range of topics related to terrestrial high performance solar cell applications in markets such as low, medium and high concentration PV (CPV), thermophotovoltaics (TPV) as well as area constrained applications e.g. in electric vehicles or consumer products.

Sub-Area 3.1: III-V Single and Multijunction Solar Cells

Sub-Area Chair(s): Ryo Tamaki, University of Tokyo, Japan
Kenneth Schmieder, Naval Research Laboratory, USA

This Sub-Area seeks to address all relevant aspects of the research and development of III-V single- and multi-junction solar cells for terrestrial applications. Topics of interest include (but are not necessarily limited to): epitaxial growth, materials design and development, solar cell architectures, single- and multi-junction devices, cell-level theoretical modeling, cell-level photon management, ultra-thin devices, wafer bonding, device processing, new manufacturing technologies, material and cell characterization, and III-V cell reliability.

Sub-Area 3.2: Low Cost, High-Performance III-V Solar Cells

Sub-Area Chair(s): Nobuaki Kojima, Toyota Technological Institute, Japan
Kevin Schulte, National Renewable Energy Laboratory, USA

Topics of interest here are broadly defined as technologies and approaches related to the achievement of lower cost III-V materials and solar cells. Papers are solicited on the growth of crystalline and polycrystalline III-V materials on alternative substrates where the substrate is not an active photovoltaic component (i.e. excluding typical single-crystal materials like Ge or III-Vs). Papers are also sought on low-cost III-V growth and deposition techniques, such as HVPE or ultra-high-rate MOVPE, including technologies to reduce precursor cost and/or consumption as well as hazardous waste treatment. Papers on epilayer lift-off and substrate re-use as well as low cost and high throughput cell processing methods are also sought. This includes e.g. development of low cost metal deposition, low cost back-mirror formation, printing of metal contacts, low cost etching and ARC deposition.

Sub-Area 2.5/3.3/4.3/6.8: Hybrid Tandem/Multijunction Solar Cells (Joint Area)

Sub-Area Chair(s): *Stephanie Essig, ZSW, Germany*
The Duong, Australian National University, Australia
Steve Albrecht, Helmholtz Zentrum Berlin, Germany

This wide-reaching Sub-Area solicits papers regarding materials, structures, and devices based on combinations of different materials (III-Vs, silicon, chalcogenides, organics, perovskites, etc.) toward the production and characterization of "hybrid" multi-junction solar cells. The full range of integration methodologies are of interest, including but not limited to monolithic epitaxy and deposition, wafer/layer bonding, and mechanical stacking, as well as the characterization of these materials, structures, and devices, from the atomic scale to the device level (and beyond), as related to their hybrid nature. Abstracts on the theory and modeling of such devices are welcome, as is work related to new module and system architectures optimized for such hybrid cells. This is a Joint Sub-Area between Areas 2, 3, 4, and 6, and will host the popular "Battle Royal Session" of previous years.

Sub-Area 3.4: Applications for High Efficiency Solar Cells including CPV

Sub-Area Chair(s): *Leah Kuritzky, Antora Energy, USA*
Nikhil Jain, X Display Company, USA

This Sub-Area seeks to address all relevant aspects of the research and development of PV systems that benefit from the unique performance of III-V and tandem solar cells. This includes the development PV modules for cars and consumer products, the development of thermophotovoltaic systems (TPV) and of all levels of concentrating photovoltaics (CPV). We invite papers dealing with module related topics such as the development of primary and secondary optics, performance modeling, module/receiver design, module-level environmental mitigation (heat, humidity, etc.), module reliability, or manufacturing advances and concerns. System-related topics of interest include (but are not necessarily limited to): low, medium and high concentration system design, concentrator assemblies, trackers, system-level characterization, soiling, system reliability, environmental influences, maintenance, energy yield and performance modeling/prediction, system-level integrated storage, life-cycle analysis, and economics/financing/markets. We specifically encourage papers on micro CPV, hybrid CPV capturing also diffuse radiation, CPV in urban environments, thermophotovoltaics, laser power conversion and all levels of high efficiency PV integration in cars and other consumer products. Topics related to employing III-V solar cells in hybrid CSP systems or for similar thermal energy storage are also welcomed.

Area 4: Silicon Photovoltaic Materials and Devices

Area Chair: Anita Ho-Baillie, The University of Sydney, Australia
Co-Chairs: Kaining Ding, Forschungs Zentrum Jülich, Germany
Zachary Holman, Arizona State University, USA
Baojie Yan, Ningbo Institute of Materials Technology and Engineering, China

Sub-Area 4.1: Silicon Material, Feedstock, Wafers and Thin Film Silicon
Sub-Area 4.2: Passivated, Carrier-Selective, and Heterojunction Contacts
Sub-Area 2.5/3.3/4.3/6.8: Hybrid Tandem/Multijunction Solar Cells (Joint Area)
Sub-Area 4.4: Metallization, Interconnection, and Module Integration
Sub-Area 4.5: Device Physics, Simulation, New Characterization Techniques and Light Management

Area Description

Silicon has been the dominant photovoltaic technology for decades, with approximately 95% market share, and yet technological developments are *accelerating* rather than slowing. Commercial cell efficiencies exceeding 22% are becoming routine as manufacturers transition to PERC structures and high-quality monocrystalline wafers, module costs have fallen below $0.3/W and are now commonly a small fraction of an installed system's cost, and the emergence of, e.g., bifacial and shingled cells has broadened the module flavors now available.

In this environment of rapid innovation, Area 4 invites contributions that define, understand, and shape the future of silicon photovoltaic science and technology. Topics of interest span the breadth of the silicon solar field, ranging from silicon purity to thin-film deposition, from electronic transport through new contact structures to high-efficiency devices, from light management to loss analysis, and from interconnection to module field degradation caused by cell deterioration. This year we especially invite abstracts from the industry talking about translation from lab to fab, challenges associated with manufacturing processes, market trends, industry roadmaps and challenges and opportunities the industry faces given the uncertainty globally. Area 4 is also accepting abstracts for a Joint Sub-Area on silicon-based tandem and multijunction devices in collaboration with Areas 3 and 6.

Sub-Area 4.1: Silicon Material, Feedstock, Wafers and Thin Film Silicon

Sub-Area Chair(s): Dan MacDonald, Australian National University, Australia
Joachim John, IMEC, Belgium

This Sub-Area covers the first part of the value chain, from silicon feedstock purification and production through crystallization and wafering, including high-performance multicrystalline silicon wafers, improved Czochralski growth, kerf-less slicing technologies, and alternative methods to produce silicon wafers such as direct wafering or epitaxy. Additionally, abstracts are welcome on the mechanical and electrical characteristics of the resulting wafers and their impact on device performance, including material changes during subsequent processing and defect engineering steps. This Sub-Area also covers thin silicon absorbers—including those of amorphous silicon, microcrystalline silicon, and related alloys focusing on their materials properties, deposition methods, cell design and performance, and degradation.

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

Sub-Area Chair(s): Kean Fong, Australian National University, Australia
James Bullock, University of Melbourne, Australia

This Sub-Area focuses on contacts formed on silicon absorbers, and specifically those layers that passivate the absorber surface (maintain high quasi-Fermi-level splitting and thus high implied open-circuit voltage) or selectively extract electrons or holes (minimize the quasi-Fermi-level drop across the contact). Abstracts are welcome on the device physics and characterization of contacts, the properties of new contact materials, and the performance of cells with contact layers such as amorphous silicon, tunnel oxides and polysilicon, and metal oxides. Abstracts concerning the deposition methods used to form these contacts are also welcome.

Sub-Area 2.5/3.3/4.3/6.8: Hybrid Tandem/Multijunction Solar Cells (Joint Area)
Sub-Area Chair(s): *Stephanie Essig, ZSW, Germany*
The Duong, Australian National University, Australia
Steve Albrecht, Helmholtz Zentrum Berlin, Germany

This wide-reaching Sub-Area solicits papers regarding materials, structures, and devices based on combinations of different materials (III-Vs, silicon, chalcogenides, organics, perovskites, etc.) toward the production and characterization of "hybrid" multi-junction solar cells. The full range of integration methodologies are of interest, including but not limited to monolithic epitaxy and deposition, wafer/layer bonding, and mechanical stacking, as well as the characterization of these materials, structures, and devices, from the atomic scale to the device level (and beyond), as related to their hybrid nature. Abstracts on the theory and modeling of such devices are welcome, as is work related to new module and system architectures optimized for such hybrid cells. This is a Joint Sub-Area between Areas 2, 3, 4, and 6, and will host the popular "Battle Royal Session" of previous years.

Sub-Area 4.4: Metallization, Interconnection, and Module Integration
Sub-Area Chair(s): *Henning Schulte-Huxel, Institute for Solar Energy Research, Germany*
Daniel Kray, Institut für Energiesystemtechnik (INES), Germany

This Sub-Area covers techniques for electrode formation, including printed metallization, plating, evaporation, dispensing or other transfer techniques, conductive adhesives, soldering, laser and thermal alloying of metals, transparent electrodes, selective doping, and contact opening for metallization The electrodes are also the interface to the subsequent module integration, and thus the Sub-Area also welcomes abstracts on mechanical adhesion, multi-wire technologies, and the interconnection of advanced cell structures like back-contact cells.

Sub-Area 4.5: Device Physics, Simulation, New Characterization Techniques and Light Management
Sub-Area Chair(s): *Olindo Isabella, Delft University of Technology, The Netherlands*
Johnson Wong, Aurora Solar Technologies, Canada

This Sub-Area focuses on understanding, quantifying, and modelling phenomena in silicon solar cells, including new interpretations of device physics, multi-dimensional models, numerical analysis of novel cell concepts, power loss measurement and mitigation strategies, computational simulations, and associated means of validation. Abstracts are also welcome on the development of new device characterization techniques, which may be based on, e.g., photoluminescence or capacitance measurements. This Sub-Area also covers light management within silicon solar cells and thin film silicon. Abstracts are also encouraged on surface engineering of silicon cells to increase photon absorption by classical, diffractive, Mie scattering and plasmonic mechanisms (regardless of whether the silicon absorber is thin), as well as approaches to reduce front-surface reflectance, reduce parasitic absorption, and reject sub-bandgap infrared light.

Area 5: Characterization Methods

Area-Chair: Laura Schelhas, National Renewable Energy Laboratory, USA
Co-Chair: Claus Zimmerman, Airbus, Germany
Ernest van Dyk, Nelson Mandela University, South Africa

Sub-Area 5.1: New Instruments, Methods and Data Analysis
Sub-Area 5.2: Advances in *Optoelectronic* Characterization Techniques
Sub-Area 5.3: Advances in *In-Situ* and *In-Line* Characterization
Sub-Area 5.4: Advanced Characterization of Photovoltaic *Materials*
Sub-Area 5.5: Advanced Characterization of Photovoltaic *Devices*
Sub-Area 5.6/8.6: Advanced Characterization of Photovoltaic *Modules and Systems* (Joint Area)
Sub-Area 5.7: Performance Testing and Standards
Sub-Area 5.8/9.4: PV Module and System Reliability Characterizations: Lab and Field Inspection Techniques (Joint Area)

Area Description

It is impossible to understand innovation in science without the support of measurements and characterization. Measurements are needed at any level of R&D and production – from the investigation of the operating principles of solar cells over to the development of standards for the performance of installed PV systems. Understanding the relations between structure, physical properties, and the resulting PV performance is an exemplary problem in materials science and engineering. Reliable and precise determination of the efficiency and thus power of solar cells and PV modules is crucial for the successful widespread deployment of photovoltaics.

Area 5 is intended for papers with focus on the latest developments in the characterization of photovoltaics. In addition, joint sessions are foreseen for papers with focus on characterization of module and systems (Area 8) and on characterization of module and system reliability (Area 9). For classical characterization of particular absorbers please submit to their respective areas.

Sub-Area 5.1: New Instruments, Methods and Data Analysis

Sub-Area Chair(s): Laura Mundt, SLAC National Accelerator Laboratory, USA
Leah Kelly, SLAC National Accelerator Laboratory, USA

This Sub-Area targets novel characterization techniques, equipment and the development of data analysis methods. It is intended to showcase the application of innovative and (pre-) commercialized techniques for characterization of photovoltaics as well as recent developments in data analysis. Papers submitted to this Sub-Area should be science or technology focused with strong technical content, rather than advertisement. Papers are sought which either present new characterization tools or data analysis methods which provide an overview and update on the state-of-the-art application of a particular technique or type of instrumentation. Papers should demonstrate the capabilities of the developed method, describe its operating principles, and/or relate how it extends existing limitations.

Sub-Area 5.2: Advances in *Optoelectronic* Characterization Techniques

Sub-Area Chair(s): Hidefumi Akiyama, University of Tokyo, Japan
Chuanxiao 'Nick' Xiao, National Renewable Energy Laboratory, USA

Papers describing any aspect of the optoelectronic response of PV materials and full devices are welcome in this Sub-Area. Examples might include papers on ellipsometry focused on the optoelectronic properties rather than on the materials properties. Luminescence or absorption based methods may fit best in this Sub-Area. Papers focusing on the technique rather than the material aspects are strongly encouraged.

Sub-Area 5.3: Advances in *In-Situ* and *In-Line* Characterization

Sub-Area Chair(s): Ana Flavia Nogueira, UNICAMP, Brazil

This involves both laboratory or synchrotron based in-situ characterization as well as in-line high throughput metrologies. This Sub-Area is intended for papers describing how to monitor PV materials during the deposition or growth steps. Papers are sought that describe measurement techniques and/or data analysis methods that are particularly suited for determining material properties and for identifying manufacturing process excursions or that provide other manufacturing-related benefits.

Sub-Area 5.4: Advanced Characterization of Photovoltaic *Materials*

Sub-Area Chair(s): James Blakesley, National Physics Laboratory, UK

This Sub-Area is on novel methods to study photovoltaic materials, their structure, properties, and how these relate to processing and performance, with a focus on the materials. Examples of topics that would fit into this area include novel scanning probe techniques, such as variants of atomic force microscopy, scanning microwave microscopy, Kelvin probes, and advanced X-ray or photoemission methods, among others. Papers that relate material properties to optical properties, electrical parameters or complete device characteristics should be addressed to Sub-Areas 5.2, 5.3 or 5.5.

Sub-Area 5.5: Advanced Characterization of Photovoltaic *Devices*

Sub-Area Chair(s): Nikos Kopidakis, National Renewable Energy Laboratory, USA

This Sub-Area focuses on methods to study photovoltaics as electronic devices rather than the materials that make them up or their optical properties. Submit papers here, which address the challenge of characterizing devices broadly. Examples include but are not limited to: capacitance methods, study of device transients, methods to understand instability in device performance, degradation of device performance, ageing etc. Development of operando measurements are also welcome in this Sub-Area.

Sub-Area 5.6/8.6: Advanced Characterization of Photovoltaic *Modules and Systems* (Joint Area)

Sub-Area Chair(s): Luo Wei, SERIS/National University of Singapore, Singapore
Natasha Hjerrild, GAF Energy, USA

Papers focusing on characterization of complete modules and systems where the nature of the device is dominated by the ensemble of microscopic behaviors distributed throughout a large area rather than the understanding of individual microscopic behaviors should be submitted in this Sub-Area. For example, papers in this Sub-Area could focus on methods such as LBIC or electroluminescence specifically as applied to understanding module performance rather than the same methods applied to small areas of device. Other examples of papers relevant to this area include adaptation of existing methods to characterize modules from emerging technologies such as perovskites.

Sub-Area 5.7: Performance Testing and Standards

Sub-Area Chair(s): Emilio Fernandez, ESA, The Netherlands

A key component of characterization, especially of cells, modules and systems, is testing of the performance and efficiency. Papers related to such characterization methods are welcome in this Sub-Area. In addition, this Sub-Area is intended for submissions related to standardization approaches to characterization. For example, standards for light flux measurement, calibration methods for simulators, testing temperatures, and other fundamental parameters of characterization that also might potentially be incorporated into future standards can be submitted here.

Sub-Area 5.8/9.4: PV Module and System Reliability Characterization: Lab and Field Inspection Techniques (Joint Area)

Sub-Area Chair(s): *Dana Sulas-Kern, National Renewable Energy Laboratory, USA*
Stephanie Moffitt, National Institute of Standards and Technology, USA

Early detection and diagnosis of PV failure modes and degradation mechanisms largely rely on advances in both field and laboratory (destructive and non-destructive) characterization techniques. This Sub-Area explicitly calls for papers presenting novel techniques, progress on deploying, as well as improved analysis and best practice, acquisition and interpretation of inspection data/measurements from existing (or emerging) field characterization techniques (I-V tracing, infrared imaging, electroluminescence imaging, UV fluorescence, etc. or a combination of these). Further to these, laboratory test/inspection methods tailored for fault detection in-situ characterization methods, sensors in correlation with accelerated reliability studies are relevant. Papers studying innovations in the fields of inspection data analytics and diagnostic algorithms, remote failure detection and wide-area inspections for PV systems are also of interest for contributions in this Sub-Area.

Area 6: Perovskite and Organic Materials and Solar Cells

Area-Chair: Philip Schulz, National Center for Scientific Research, France
Co-Chairs: Annalisa Bruno, Nanyang University, Singapore
Jeffrey Christians, Hope College, USA

Sub-Area 6.1: All-Perovskite Tandem Solar Cells
Sub-Area 6.2: Stability of Perovskite Materials and Solar Cells
Sub-Area 6.3: Scale-Up and Large-Area Fabrication of Perovskite Solar Cells
Sub-Area 6.4: Organic and Dye-Sensitized Solar Cells
Sub-Area 6.5: Advances in Perovskite Solar Cell Development
Sub-Area 6.6: Lead-Free and All Inorganic Absorbers for Perovskite Solar Cells
Sub-Area 6.7: Lower-Dimensionality Perovskite Materials and Solar Cells
Sub-Area 3.3/4.3/6.8: Hybrid Tandem/Multijunction Solar Cells (Joint Area)

Area Description

This focus area covers the latest scientific and technical progress of halide perovskite, organic, and hybrid solar cells. Organic and organic-inorganic hybrid perovskite materials are rising stars for solar cell and optoelectronic applications. Based on abundant materials and scalable coating technologies, these emerging PV technologies show potential for low-cost, lightweight, and flexible solar power generation and will soon have to prove their viability in the market with a promising combination of efficiency, stability, and in some cases environmental benignity at scale. Within only one decade of development, the certified power conversion efficiency of perovskite solar cells has reached over 25%, while the efficiency of organic solar cells is now also exceeding 17%. Particularly noteworthy are the recent developments concerning the stability of halide perovskite-based solar cells, which result from intense research on material properties (composition, structure, etc.) and device layout (architecture, interfaces, etc.). Although the current state-of-the-art still has a long way to go in order to compete with commercialized solar cells, research on degradation mechanisms and improved cell stability reported in recent publications do suggest that long-term stability could be achievable. In addition, new types of perovskite materials are constantly being explored and developed with the aim of replacing lead (e.g. in double perovskite materials) or to increase film stability (by using mixed dimensional perovskites). Another important research trend is the development of fabrication technologies for high throughput fabrication (e.g. slot die coating, spray coating, soft cover technique, vacuum evaporation and chemical vapor deposition, etc.), which would pave the way towards high throughput large area perovskite solar cells and modules with minimal device-to-device variations and is therefore moving this technology closer to commercialization.

Area 6 presents itself as an ideal forum for researchers in the field to present their progress in the area of photovoltaic application and to exchange their views, discuss current challenges, and identify future research topics. The rapid development of organic and perovskite materials and devices in the past few years marks the strong foundation for this Area. To facilitate a comprehensive discussion on the broad scope of aspects, Area 6 spans over various principal topic areas as listed below.

Sub-Area 6.1: All-Perovskite Tandem Solar Cells

Sub-Area Chair(s): Jianghui Zheng, University of New South Wales, Australia

Sub-Area 6.1 covers progress on the development of all-perovskite tandem and multijunction solar cells with the potential to reach power conversion efficiencies beyond the S-Q limit of single junction cells. The focus of this Sub-Area is on novel concepts, solar cell fabrication, device testing, and module implementation. We thus welcome contributions, which feature experimental and theoretical work on proof-of-concepts, device implementation, and the interplay between the various absorber films and interlayers in the cell layout.

Sub-Area 6.2: Stability of Perovskite Materials and Solar Cells
Sub-Area Chair(s): *Solenn Berson, Alternative Energies and Atomic Energy Commission, France*
Erin Sanehira, Hunt Energy Enterprises Solar, USA

Reaching a high level of reliability and durability is key to the continued development of perovskite solar cell technology. Hence, sub-Area 6.2 is dedicated to the progress of perovskite solar cell stability concerning all device components, i.e. from the perovskite absorber layer to the various interlayers and contacts. Discussed topics thus include intrinsic and extrinsic degradation mechanisms, efficiency loss issues in perovskite photovoltaics, and strategies for improved stability. Work from a broad scope of research is welcome, ranging from fundamental studies on degradation processes at the nanoscale to industrial encapsulation strategies and durability testing.

Sub-Area 6.3: Scale-Up and Large-Area Fabrication of Perovskite Solar Cells
Sub-Area Chair(s): *Jean Rousset, Electricité de France, France*
Maikel van Hest, National Renewable Energy Laboratory, USA

With the growing demand for utility scale implementation of perovskite solar cell modules, sub-Area 6.3 has its focus on the development of scale-up, large-area fabrication and processing, high-throughput, as well as environmentally friendly and green manufacturing technologies for large-area perovskite solar cells. The range of topics in this Sub-Area covers, but is not limited to, perovskite module design, module testing, fabrication techniques, process chain evaluation, and life cycle assessment.

Sub-Area 6.4: Organic and Dye-Sensitized Solar Cells
Sub-Area Chair(s): *Denis Tondelier, Ecole Polytechnique, France*

Sub-Area 6.4 covers progress on the development of pure organic solar cells and dye-sensitized solar cells, including material optimization, the use of fullerene and non-fullerene based molecules, new charge transport materials and device designs. The Sub-Area will feature fundamental studies, as well as solar cell fabrication and testing. Hence, we welcome a broad range of submissions from first principles design and synthesis of new donor and acceptor materials, over methods of controlling and characterizing their microstructure in thin films, to finally device optimization, stability and scalability.

Sub-Area 6.5: Advances in Perovskite Solar Cell Development
Sub-Area Chair(s): *Nakita Noel, Princeton University, USA*
Hyun Suk Yung, Sungkyunkwan University, Korea

Sub-Area 6.5 covers the latest developments in organic-inorganic hybrid and fully inorganic halide perovskite based solar cells. The rapid progress in this material class for solar cells came as a surprise to many as power conversion efficiencies of perovskite solar cells are already comparable to those of established thin film technologies. The optoelectronic properties of the materials are highly tunable, making them attractive for a range of applications including building-integrated PV and tandem solar cells. This sub-Area focuses especially on the tunability offered by substitution of elemental and molecular components in the perovskite structure, which may enable better performance, new device architectures, design of interfaces in the layer stack, advances in fabrication routes, and novel processing steps. We invite contributions from the broad range of topics relating to halide perovskite-based PV.

Sub-Area 6.6: Lead-Free and All-Inorganic Absorbers for Perovskite Solar Cells
Sub-Area Chair(s): *Ashley Marshall, University of Oxford, UK*
Yixin Zhao, Shanghai Jiao Tong University, China

Substituting lead in the absorber materials has become a primary target to increase the sustainability of perovskite solar cell fabrication. In Sub-Area 6.6 we are looking forward to receiving contributions on the development of lead-free perovskite solar cells, including work on the absorber material design, solar cell optimization and device stability. Featured studies could hence focus on fundamental aspects of lead-free perovskites and perovskite-like absorber materials, as well as theoretical and experimental work on perovskite solar cells, that are either entirely lead-free or feature a reduced amount of lead in the absorber layer.

Sub-Area 6.7: Low-Dimensional Perovskite Materials and Solar Cells
Sub-Area Chair(s): *Giulia Grancini, University of Pavia, Italy*

Low-dimensional halide perovskite absorbers offer a unique route to improve the stability of perovskite solar cells, either as additives in the precursor solution or as dedicated interlayer in the devices stack. In particular, Ruddlesen-Popper (RP), Dion-Jacobson (DJ) and perovskites with alternating cations in the interlayer space (API) types of 2D perovskite materials have been very popular in recent years. Sub-Area 6.7 covers progress on the development of perovskite materials with low or mixed dimensionality and solar cells that integrate these variants in the absorber film or at the interfaces.

Sub-Area 2.5/3.3/4.3/6.8: Hybrid Tandem/Multijunction Solar Cells (Joint Area)
Sub-Area Chair(s): *Stephanie Essig, ZSW, Germany*
The Duong, Australian National University, Australia
Steve Albrecht, Helmholtz Zentrum Berlin, Germany

This wide-reaching Sub-Area solicits papers regarding materials, structures, and devices based on combinations of different materials (III-Vs, silicon, chalcogenides, organics, perovskites, etc.) toward the production and characterization of “hybrid” multi-junction solar cells. The full range of integration methodologies are of interest, including but not limited to monolithic epitaxy and deposition, wafer/layer bonding, and mechanical stacking, as well as the characterization of these materials, structures, and devices, from the atomic scale to the device level (and beyond), as related to their hybrid nature. Abstracts on the theory and modeling of such devices are welcome, as is work related to new module and system architectures optimized for such hybrid cells. This is a Joint Sub-Area between Areas 2, 3, 4, and 6, and will host the popular “Battle Royal Session” of previous years.

Area 7: Space and Specialty Technologies

Area-Chair: Jeremiah McNatt, NASA, USA
Co-Chairs: Mitsuru Imaizumi, JAXA, Japan
Roberta Campesato, CESI, Italy

Sub-Area 7.1: Space Solar Cells: Including Radiation Effects and Calibration
Sub-Area 7.2: Space PV Systems: Including Panels, Arrays, Structures, and Space Environment Impacts
Sub-Area 7.3: Flight Experience and Reliability of Space Photovoltaic Power Systems
Sub-Area 7.4: Novel Space PV Technologies: Flexible, Lightweight and Cost-Effective Solar Power for Space and Terrestrial UAV and High-Altitude Applications

Area Description

Area 7 is concerned with all aspects of photovoltaic power generation subjected to extreme environments. The space and near space environment combines UV light, particle radiation, extreme temperatures and vacuum, to name a few of the environmental factors. Papers are thus welcome that deal with the entire breadth of PV under these conditions, from cell and material technologies up to complete systems. The associated Sub-Areas are Space Solar Cells and Space PV Systems, which includes solar panel and blanket technology as well as solar arrays and structures. With typical long lifetimes, e.g. up to 15 years in GEO, combined with the inability to service the space PV systems, reliability and the correct prediction of the on-orbit performance is of key importance and will be covered in the Flight Experience and Reliability Sub-Area. Of particular interest are ground based degradation experiments, cell and material degradation studies, flight experiments, and on-orbit measurements.

Area 7 also welcomes a wide range of specialty technologies such as mobile solar power (MSP), flexible and lightweight PV, and PV that operates in non-traditional environments, such as on UAVs and automobiles. These topics are of interest for the Specialty Technologies Sub-Area.

We also highly encourage contributions from students who are working in relevant research areas. We invite your papers on any subjects related to space PV described above, and look forward to your contribution!

Sub-Area 7.1: Space Solar Cells: Including Radiation Effects and Calibration

Sub-Area Chair(s): Pilar Espinet Gonzalez, California Institute of Technology, USA

This Sub-Area focuses on photovoltaic device approaches, modelling, and recent developments in high performance photovoltaic materials and devices for space applications. Advanced multijunction solar cells (with three or more junctions) with performance reaching towards 33% end of life efficiency that are in development worldwide are of particular interest. Although III-V multijunction architectures dominate space PV, this Sub-Area is not limited to this material system nor is it limited to multijunction cells. Radiation hardening technologies that enable longer on-orbit capability are sought in this Sub-Area. Contributions dealing with the AM0 measurement and calibration of solar cells also belong to this area.

Sub-Area 7.2: Space PV Systems: Including Panels, Arrays, Structures, and Space Environment Impacts

Sub-Area Chair(s): Sean Wood, SpaceX, USA
Robert Walters, Air Force Research Laboratory, USA

This Sub-Area focuses on technology developments associated with space PV systems at all component levels required for providing power on a spacecraft. This Sub-Area covers integration of space solar cells onto rigid panels and flexible blankets all the way through advanced solar array concepts. Technologies required for electrostatic discharge control, stabilization against ionizing radiation (e.g., UV, particles), interactions with electric propulsion subsystems and development of space solar concentrator technologies, incorporating both the optical concentrating element as well as the solar cell thermal control element are included as well. Also of interest are papers that describe 'New Space' approaches to lower cost, standardized solar panels both fixed and deployable, for smallsat (including Cubesat) constellations.

Contributions are sought for all power classes, from the microsatellite power range up to the several 100 kW range, with design consideration from low to high voltage arrays, which are required for large spacecraft for new telecommunication services or solar electric propelled deep space missions. To this end, papers with a mechanical focus are explicitly encouraged in this area. Also welcome are contributions that deal with platform aspects and their interaction with the solar array.

Sub-Area 7.3: Flight Experience and Reliability of Space Photovoltaic Power Systems
Sub-Area Chair(s): Claus Zimmerman, Airbus, Germany

This Sub-Area deals with the on-orbit performance and reliability of space photovoltaic power systems and components. An essential aspect are the results from on-orbit experimentation and operation of PV power systems and their analyses. Reliability assessments via experimentally determined degradation behavior, e.g. due to particle irradiation or contamination, are encouraged. In this context, papers addressing the end-of-life performance with the help of degradation modelling are also of high interest. Papers dealing with reliability improvements due to particular qualification approaches and test standards are welcome. Papers covering cell and power system testing using CubeSats are also encouraged.

Sub-Area 7.4: Specialty PV: Flexible, Lightweight and Cost-effective Mobile Solar Power for Terrestrial, UAV and High-altitude Applications
Sub-Area Chair(s): Lyndsey McMillon-Brown, NASA, USA

This Sub-Area covers progress on the development of novel solar cell and array materials, emerging hybrid devices, and strategies for reducing costs for space and high altitude missions. This includes flexible and lightweight solar cells, sheets and related integration systems for terrestrial, UAV and high-altitude applications. Papers are sought that describe the development of thin cell technologies including material growth, cell fabrication and testing. Papers covering developments of flexible solar sheet fabrication methods, studies on improvement of sheet durability; ruggedness and overall energy generation are invited. Papers discussing cost reduction technologies for both cell production and cell integration for use in non-traditional environments are encouraged. Development of photovoltaic sheets for systems applications such as battery charging, portable power, powering flexible electronics, and emerging technologies such as PV for automobiles covering both the military and civilian energy power application are of interest in this Sub-Area for their potential use in future space missions.

Area 8: PV Modules, Manufacturing, Systems and Applications

Area Chair: Bonna Newman, TNO Energy Transition, Netherlands
Co-Chairs: Zhe Liu, Massachusetts Institute of Technology, USA
Zi Ouyang, University of New South Wales & Nanjing AGG Energy Co., Australia/China

Sub-Area 8.1: Module Materials, Design, and Manufacturing
Sub-Area 8.2: System Design, Optimization and Performance
Sub-Area 8.3: Modelling and Predicting Energy Yield
Sub-Area 8.4: Strategies for Performance Monitoring and Rating
Sub-Area 8.5: Novel Applications and Integration of PV
Sub-Area 5.6/8.6: Characterization Techniques for PV Modules and Systems (Joint Area)

Area Description

The PV module is the mechanical support and electrical connection of the cells. It offers both electrical protection and protection from the environment. It is the primary product around which a PV system is based and it can be modified and optimized for locations, environments, and applications. As such, the PV module represents the cornerstone product of the PV industry. Recently, innovations in module construction 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. New materials, assembly technologies, and structures are being developed for PV modules and will further reduce costs and increase performance. For example, bifacial modules are becoming an increasingly attractive way to reduce cost via increased energy yield. Additionally, customers and operators are seeking and utilizing energy yield prediction methods to reduce investment risk. Improved energy yield estimates will reduce some of the soft costs in financing and thus further reducing the LCOE. Area 8 is seeking papers describing significant advances in module technology, PV module design and manufacturing, methods for forecasting and modelling energy yield and performance, innovative PV deployment and new applications, as well as testing and system monitoring.

A detailed description of each Sub-Area is provided below. For each Sub-Area, papers reporting completed work, accompanied by validation from the field, laboratory testing, or comprehensive modelling are encouraged and welcome.

Sub-Area 8.1: Module Materials, Design, and Manufacturing

Sub-Area Chair(s): Zhe Liu, Massachusetts Institute of Technology, USA

In Sub-Area 8.1, abstracts are invited that describe new materials and methods for module production with particular interest on: new materials for backsheets, encapsulants, glass, or interconnects; new techniques for module assembly to reduce cost, increase efficiency or enhance reliability; new designs for bifacial applications; module adjustments and optimization for extreme environments; and novel module electrical configurations. In coordination with Sub-Area 9.4, we particularly welcome submissions describing state-of-art or new methods for module manufacturing quality control, including quality assurance of module materials and subcomponents; statistical process control; and automation of module assembly.

Sub-Area 8.2: System Design, Optimization, and Performance

Sub-Area Chair(s): Eric Gerritsen, CEA/Ideafix, France

In Sub-Area 8.2, abstracts are invited that describe new concepts for complete photovoltaic systems, methods of system optimization, field results, full life-cycle analysis of system components and system performance analysis. System optimization could be for energy yield, LCOE, self-consumption, LCA and end of life considerations or other aspects important for a specific application or environment. In particular, we welcome submissions describing system design and optimizations for bifacial modules, trackers in PV systems, floating PV, grid-connected or off-grid systems and performance comparisons with the system performance models. Note that the papers related to forecasting and solar resource should be submitted under Area 9 and power electronics methods for optimization in Sub-Area 9.4 or Area 11.

Sub-Area 8.3: Modelling and Predicting Energy Yield

Sub-Area Chair(s): Gregory Kimball, SunPower, USA

Sub-Area 8.3 focuses on PV methods of module modelling and the prediction of produced energy. Abstracts relating to mechanical, thermal and electrical modelling of PV modules and systems including methods for determining parameters for these models are also welcome. Abstracts of particular interest are those describing: methods for determining model parameters from laboratory and/or outdoor characterization for different modules and installation types; models for the effect of solar spectrum on module output; and methods for estimating system losses, e.g. shading losses, or temperature variations, BOS related losses, etc.

Sub-Area 8.4: Strategies for Performance Monitoring and Rating

Sub-Area Chair(s): Kendra Conrad, Array Technologies, USA

Sub-Area 8.4 welcomes abstracts reporting novel methods and technologies for system or individual module monitoring during operation, improved techniques for system performance testing, and research describing novel analysis strategies to extract the information on system or module health and performance from available monitored data. We welcome abstracts describing: advances in or evaluations of methods for determination of plant performance metrics; procedures for conducting commissioning and acceptance tests. We particularly invite abstracts reporting efforts to compare and/or harmonize among the various standards for system testing and rating.

Sub-Area 8.5: Novel Applications and Integration of PV

Sub-Area Chair(s): Zi Ouyang, University of New South Wales & Nanjing AGG Energy Co., Australia/China

Sub-Area 8.5 welcomes abstracts describing recent advances in building integrated PV systems (BIPV), off-grid PV systems, hybrid systems, mini/micro-grids, DC end-use systems, mobility and transportation systems, infrastructure-integrated PV, agri-PV, and other not-traditional PV applications. In particular, we welcome abstracts reporting new innovations, visions for future development, and advanced analyses of the cost reduction potential for building related PV applications, advances in building design tools with integrated PV modelling functionality, as well as reports of building power system performance. We are particularly interested in topics covering design and engineering advances, novel requirements, dual-use studies, and results from system simulations and field demonstration. In addition, we would like to emphasize papers that have a goal of leveraging the distributed nature of solar PV to enhance social equity. Note that papers related to floating PV or PV on water should be submitted in Sub-Areas 8.2, 8.3, or 8.4 where applicable.

Sub-Area 5.6/8.6: Advanced Characterization of Photovoltaic *Modules and Systems* (Joint Area)

Sub-Area Chair(s): Luo Wei, SERIS/National University of Singapore, Singapore

Natasha Hjerrild, GAF Energy, USA

Papers focusing on characterization of complete modules and systems where the nature of the device is dominated by the ensemble of microscopic behaviors distributed throughout a large area rather than the understanding of individual microscopic behaviors should be submitted in this Sub-Area. For example, papers in this Sub-Area could focus on methods such as LBIC or electroluminescence specifically as applied to understanding module performance rather than the same methods applied to small areas of device. Other examples of papers relevant to this area include adaptation of existing methods to characterize modules from emerging technologies such as perovskites.

Area 9: Module and System Reliability

Area Chair: Teresa M. Barnes, National Renewable Energy Laboratory, USA
Co-Chairs: Karl-Anders Weiß, Fraunhofer ISE, Germany
Thomas Reindl, SERIS, Singapore

Sub-Area 9.1: PV Materials and Module Durability and Accelerated Testing Methods
Sub-Area 9.2: Reliability and Safety of Power Electronics, Balance of System, and Connected Storage Components
Sub-Area 9.3: Field Experiences in PV Systems
Sub-Area 5.8/9.4: PV Module and System Reliability Characterizations: Lab and Field Inspection Techniques (Joint Area)
Sub-Area 9.5: Effects and Mitigation of Soiling on PV Systems
Sub-Area 9.6: Module and System Reliability in the Circular Economy

Area Description

Long-term durability, reliability of PV systems is critical for reliable and efficient energy production as the share of renewables increases in our energy mix. Moreover, the systems delivering the expected return on investment for all players along the value chain provide the industrial driver for continued growth. PV system lifetimes are extending to 30-40 years and are often deployed in harsh weather conditions. The industry is both risk averse requiring all new technologies (from PV, cell through module materials, components and systems elements) to prove their robustness in extensive testing before field deployment and rapidly adopting new technologies faster than they can be field tested. More systems are being deployed on areas subject to harsh weather including high winds, flooding, hail, lightening and fire, which requires additional diligence for resilient system design. Finally, long-lasting and reliable PV systems are also the foundation for an ecologically sustainable PV system. Area 9 is now also encouraging papers on solar + energy storage systems.

Within this context, Area 9 considers the reliability and resiliency of all types of PV systems and their components and technologies as well as impact of materials, processing, installation and operations throughout the value chain. Topics especially critical to the success of the PV industry include comprehensive reporting of failures and degradation rates on the field, and in-depth understanding of physics/chemistry of degradation/failure modes for current and next generation PV materials and technologies. Inverter and BOS failures are frequently reported in the field and are of special interest in this Area. This serves as a foundation for development of adapted accelerated tests, and the validation of those tests' ability to correlate with outcomes in the field. Discussion of best practices in Design-for-Reliability, Failure Mode and Effect Analysis, manufacturing Quality Assurance and Safety measures, and resiliency are within the interest of the Area; as well as the latest development of science-based standards and test protocols.

Submission of papers on detailed scientific research studies as well as visionary papers addressing the full range of these topics are invited. Area 9 has been divided into six subareas, as presented below. This area may also host joint sessions with other Areas related to characterization and balance of system components.

Sub-Area 9.1: PV Materials and Module Durability and Accelerated Testing Methods

Sub-Area Chair(s): Pending

Module and module components are subject to high temperatures, thermal cycling, humidity, ultraviolet light, electrical, and mechanical stresses. These can result in a variety of failure mechanisms such as glass corrosion, encapsulant browning, EVA yellowing, backsheet cracking, bubbling and delamination, interconnect fatigue and corrosion, frame corrosion and fatigue, bypass diode failure, junction box failure, and cable and connector failure and etc. Submissions are encouraged on experimental studies of the chemistry and physics of these or other module failure mechanisms, accelerated stress tests and method to extract acceleration factors, modelling of degradation and failure rates, interfacial and multi-scale module simulations. Reports linking failure modes to material, module manufacturing, process parameters and insights in critical controls are invited. Studies of degradation rates in recently developed high performance modules using high efficiency mono, bifacial and/or tandem cells (PERx, n-type, HIT, IBC, large wafers/cells etc.), high density module designs (shingling, tiling, cut cells, close spacing, bifacial, large modules) and next generation module materials (AR-coatings, backsheets, encapsulants etc.) are of interest, as are studies demonstrating field-relevant accelerated testing. Papers presenting detailed Failure Mode and Effect Analysis (FMEA) to assess the potential failure modes and development of adapted tests are also of interest. Studies presenting reliability of modules and materials for novel applications and conditions (lightweight, floating, tracked), and integrated PV solutions (BIPV, ViPV, IIPV) are of interest.

Sub-Area 9.2: Reliability and Safety of Power Electronics, Balance of System, and Connected Storage Components

Sub-Area Chair(s): Jennifer Braid, Sandia National Laboratory, USA

The field durability of PV power electronics is an important factor in overall system lifetime and strongly impact its cost. PV system power electronic and BOS components (including trackers, inverters, converters, cables, combiner boxes, bypass diodes, optimizers etc.) are subject to thermal cycling, heat and humidity, freezing and moisture, electrical bias, ultraviolet light, and mechanical stresses that result in a variety of failure mechanisms such as corrosion, metallization fatigue, electronic component failure, aging of materials, and breakage. The exact nature of the degradation will vary with the type of component and the environmental conditions during operation. Inverters may experience problems with transistors, cooling or software failures. This Sub-area welcomes papers on identification and elucidation of the failure mechanisms, accelerated stress tests and acceleration factors, modelling of degradation and failure rates, climate specific effects, understanding the effects of system design (voltage, mechanical, string/central inverter) on reliability, extreme and routine weather events, and critical quality controls in manufacturing. High voltage system designs, high DC/AC ratios, string vs. central inverters, connector studies, and tracker performance studies are strongly encouraged. Interlinked module to system component level mechanisms such as potential induced degradation, the impact of higher power and bifacial modules on power electronics reliability, localized environmental effects such as saltwater on electronics, and integration of module electronics into PV modules are one of the focus topics. Accelerated testing, system design, safety, and early performance studies of DC and AC coupled storage are of strong recent interest.

Improved functionality and documentation of field reliability studies for power electronics will be another focus of this Sub-Area, as well as novel methods for improved safety (fire prevention, arc detection/mitigation, shock hazards, ground and series arc faults, mechanical integrity).

Sub-Area 9.3: Field Experiences in PV Systems

Sub-Area Chair(s): Pending

This Sub-Area focuses on statistics of types of failures, data analysis techniques for field data for large-scale and small-scale systems, analysis of mechanisms of observed degradation and failures, electrical and mechanical impacts of failures, degradation rates models, safety and operational failures from large PV systems, expected vs. actual field performance, and long-term operation models of PV plants. Submissions may include (but are not limited to) analysis of field observations from deployments of all PV technologies, methods of analysis of such data, experimental approach and energy yield predictions, best practices and technical/economic insights into operations and maintenance, and models or reviews that paint the big picture of what is happening in the real world. Papers studying PV system-level availability, in diverse climatic and site conditions, reliability related to extreme environmental events, mounting methods, and interactive effects are encouraged. Innovations in the field of system data analytics and remote failure detection are also of interest. This area encourages submissions of field experiences with inverter or BOS failure, repowering, field repair, energy storage, varying DC/AC ratios, and bifacial field performance.

Sub-Area 5.8/9.4: PV Module and System Reliability Characterization: Lab and Field Inspection Techniques (Joint Area)

Sub-Area Chair(s): Dana Sulas-Kern, National Renewable Energy Laboratory, USA
Stephanie Moffitt, National Institute of Standards and Technology, USA

Early detection and diagnosis of PV failure modes and degradation mechanisms largely rely on advances in both field and laboratory (destructive and non-destructive) characterization techniques. This Sub-Area explicitly calls for papers presenting novel techniques, progress on deploying, as well as improved analysis and best practice, acquisition and interpretation of inspection data/measurements from existing (or emerging) field characterization techniques (I-V tracing, infrared imaging, electroluminescence imaging, UV fluorescence, etc. or a combination of these). Further to these, laboratory test/inspection methods tailored for fault detection in-situ characterization methods, sensors in correlation with accelerated reliability studies are relevant. Papers studying innovations in the fields of inspection data analytics and diagnostic algorithms, remote failure detection and wide-area inspections for PV systems are also of interest for contributions in this Sub-Area.

Sub-Area 9.5: Effects and Mitigation of Soiling on PV Systems

Sub-Area Chair(s): Pending

Soiling can be a major factor in PV power plant performance. This Sub-Area focuses on studies of soiling effects on PV systems, ground- and satellite-based forecasting of soiling rates, methods for evaluating such rates, cleaning solutions, materials for anti-soiling coatings, tests for anti-soiling coatings (both artificial soiling to test functionality and abrasion testing to test for durability). The Sub-Area also welcomes technical and/or economic studies with respect to soiling mitigation measures (cleaning, anti-soiling retrofit solutions, etc.) and their implementation within PV plant designs and O&M plans, modelling and predictability of soiling losses for different climate conditions and soiling composition, as well as studies on the fundamental physics of soiling dust growth and its modelling in PV installations.

Sub-Area 9.6/12.5: Module and System Reliability in the Circular Economy (Joint Area)

Sub-Area Chair(s): Eszter Vorashazi, IMEC, Belgium

Developing a circular economy for PV modules, components, and systems becomes increasingly important as deployments continue to grow. One of the biggest challenges for a circular economy is defining and quantifying what we mean by “circularity”. This area welcomes papers on how to define, quantify, and measure circularity for PV systems and components. Maximizing component and system useful life is one way to make PV more circular. This sub area encourages papers on how system reliability and resiliency affect circularity, and approaches to extending the useful life such as optimized O&M, repair, refurbishing, repowering, and reuse/resale. Safety and performance testing of repaired or re-sold components and systems are critical and of strong interest. Developing circular supply chains reduces waste at end of life, and it may have significant benefits for a more resilient and diverse supply chain at all stages from initial manufacturing through operations. submissions on reducing the amount of virgin feedstocks, repairable systems/components, use of recycled feedstocks or materials, supply chain resiliency, and backwards compatibility or spare parts are encouraged. End of life management issues including recycling, material recovery, and system reuse.

Area 10: Power Electronics and Grid Integration

Area Chair: Anamika Dubey, Washington State University, USA
Co-Chairs: Fernanda Trindade, University of Campinas, Brazil
Sandeep Anand, Indian Institute of Technology Bombay, India

Sub-Area 10.1: Power Converter Topologies and Design
Sub-Area 10.2: Power Converter Modelling and Control
Sub-Area 10.3: Ancillary Services and Grid Support Functionalities
Sub Area 10.4: Optimization and Data-driven Methods
Sub-Area 10.5: Real-time Simulation and Hardware-in-the-loop Testing
Sub-Area 10.6: Distribution System Operation and Control
Sub-Area 10.7: Microgrids
Sub-Area 10.8/11.3/12.4: Advanced Resource Management – Towards 100% Renewable Electricity (Joint Area)

Area Description

As PV installations become more widespread, the demands on the power electronics designed to interface solar panels to the grid will continue to increase. Likewise, the rapid integration of massive levels of distributed PV penetrations motivates new challenges to managing grid operations. At the component level, advanced inverter functionality and energy storage will enhance grid stability to manage the fast-changing phenomenon by an even faster response to control and stabilize the grid. Further, advanced topologies and controls will continue to improve power converter performance and reduce system cost. At the system level, the optimization and management of distributed PVs and other grid resources will continue to support the integration of large penetrations of renewables and enable the extraction of grid services and grid support functionalities. The increasingly active nature of the power distribution systems will motivate new methods for distribution grid operations requiring proactive management of the variables generation resources.

The power electronics and power systems community are encouraged to submit contributions addressing the full range of scientific and technical contributions to the field of PV integration into the grid. Of particular interest is a special Joint Session with Areas 10, 11, and 12 inviting publications on topics related to the "advanced resource management towards 100% renewable electricity," representing new opportunities for publication at the PVSC.

Sub-Area 10.1: Power Converter Topologies and Design

Sub-Area Chair(s): Ghanshyamsinh Gohil, Hitachi ABB Power Grids, USA

This Sub-Area solicits papers describing new converter designs for DC-DC and inverter applications for PV energy conversion. Emphasis is placed on novel circuit designs, magnetics, wide-bandgap semiconductor materials, and other innovations in component-level converter design. Such designs promise higher efficiency, improved power density, increased switching frequencies, and higher voltage operation. Results with circuit analysis, experimental validation, and field testing will be featured.

Sub-Area 10.2: Power Converter Modelling and Control

Sub-Area Chair(s): Wei Du, Pacific Northwest National Laboratories, USA

PV systems and their associated power electronics interfaces require accurate controls in order to operate. Advanced power electronics controls are needed at the individual converter level, multi-converter-based microgrids, and large PV power plants. Modern control algorithms must accommodate fast dynamics, nonlinearities, and complex system interactions. This Sub-Area invites contributions on any facet of modelling and control of power electronics for PV converters, microgrids, and power systems.

Sub-Area 10.3: Ancillary Services and Grid Support Functionalities

Sub-Area Chair(s): *Panos Kotsampopoulos, National Technical University of Athens, Greece*

High penetration of both distributed and utility-scale PV systems on the electrical power grid and the variability and unpredictability of PV output introduces a host of challenges for utilities and independent system operators to manage. This Sub-Area solicits papers addressing aspects of grid integration related to advanced inverter functionality (voltage and frequency regulation, grid-forming control) and operation of battery storage technologies and other emergent technologies.

Sub-Area 10.4: Optimization and Data-driven Methods

Sub-Area Chair(s): *Christine Chen, University of British Columbia, Canada*

The reliable and economic operation of integrated power systems is challenged by fast PV dynamics. This calls for advanced monitoring and optimization strategies that adapt to rapid variations in operating point by, e.g., leveraging real-time measurements collected from advanced sensors across the power system. This Sub-Area solicits contributions in design, implementation, and verification of tools that enable power availability, economic operation, real-time monitoring, and other system-level objectives.

Sub-Area 10.5: Real-time Simulation and Hardware-in-the-loop Testing

Sub-Area Chair(s): *Prabakar Kumaraguru, National Renewable Energy Laboratory, USA*

Crucial to the design and operation of PV integrated systems are sophisticated computer models and programs to simulate normal and contingency scenarios. Significant computational hurdles are presented by power-electronic interfaces, the mix of AC and DC components, and complex subsystem interactions. This Sub-Area seeks original contributions in the design and implementation of real-time simulators along with testing of hardware devices within the real-time simulation environment.

Sub-Area 10.6: Distribution System Operation and Control

Sub-Area Chair(s): *Sumit Paudyal, Florida International University, USA*

Wide integration of distributed PV generation and fast-acting power converters introduce unprecedented variability and unpredictability on existing distribution system operation. This Sub-Area seeks papers that address problems arising from the integration of PV into distribution systems, including inverter control, voltage regulation, volt-var optimization, power quality, protection, PV sizing and placement, and other pertinent issues.

Sub-Area 10.7: Microgrids

Sub-Area Chair(s): *Pedro P. Vergara, Delft University of Technology, The Netherlands*

Microgrids offer an effective way of combining and controlling renewable energy sources, such as solar PVs. Capability to operate in both islanded and grid-connected mode, a wide range of power handling, and integration of different types of sources and storage, make it a suitable solution for both urban and remote areas. This Sub-Area invites original research papers in the area of solar PV integration using AC and DC microgrids. Topics such as secondary control, power-sharing, voltage & frequency regulation, power quality, stability, and islanded operation of solar PV based microgrids, are of interest to this Sub-Area.

Sub-Area 10.8/11.3/12.4: Advanced Resource Management – Towards 100% Renewable Electricity (Joint Area)

Sub-Area Chair(s): *Marta Victoria Perez, Aarhus University, Denmark*
Matt Stone, Australian National University, Australia
Keiichiro Sakurai, AIST, Japan

PV installations are on the rise. Estimates see a cumulative capacity of 633GW for 2019, and more than 1TW by 2023. Regions across the world are experiencing the impact of significant penetration from PV and wind in their electrical networks and markets. In this Sub-Area, we want to address what technologies, concepts and policies are most beneficial in addressing the challenges of the energy transition. For the next conference, we will focus on regional and national strategies to approach or reach 100% renewables. We especially encourage contributions from students and aim to cover diverse regions and approaches.

Area 11: Solar Resource for PV and Forecasting

Area Chair: Ian Marius Peters, Forschungszentrum Jülich, Germany
Co-Chairs: Marta Victoria Perez, Aarhus University, Denmark
Ricardo Rüther, University of Florianopolis, Brazil

Sub-Area 11.1: Solar Resource – Characterization, Assessment and Variability Modelling
Sub-Area 11.2: Forecasting – Solar Resource or PV Power Output from Minutes to Days Ahead
Sub-Area 10.8/11.3/12.4: Advanced Resource Management – Towards 100% Renewable Electricity (Joint Area)

Area Description

Solar resource measurement and forecasting are essential for evaluating technical and financial performance in PV applications, and uncertainties related to the solar resource contribute directly to uncertainties in economic viability. This research area covers technologies and methods to quantify and model solar irradiance with a particular focus on applications in the PV sector.

Sub-Area 11.1: Solar Resource – Characterization, Assessment and Variability Modelling

Sub-Area Chair(s): Merlinde Kay, University of New South Wales, Australia
Ian Marius Peters, FZ-Jülich, Germany

Understanding the available solar resource is essential for technical and economic planning of a PV system. Technological advancements in characterizing and analyzing the available solar resource, as well as other relevant environmental factors, allows for improved PV modelling techniques and system optimization. In this Sub-Area, innovations in methodology of solar resource assessment, characterization, and variability modelling are covered. The chief objective should be reducing PV efficiency loss and modelling uncertainty. We explicitly include analyses of all relevant factors for PV modelling, here – for example analyses of the solar spectrum, correlations between solar resource and temperature, impacts of humidity and aerosols, soiling rates, albedo measurement practices, as well as their impacts on PV system performance.

Sub-Area 11.2: Forecasting – Solar Resource or PV Power Output from Minutes to Days Ahead

Sub-Area Chair(s): Ricardo Rühther, University of Florianopolis, Brazil

As PV panels generate increasing amounts of the world's electricity, forecasting becomes ever more important. Highly accurate forecasting of the expected power output and its uncertainty is required for grid management and economic assessment. In this Sub-Area, all topics related to improvements in our ability to predict PV power output and solar resource are invited. We especially welcome contributions that highlight innovations in mathematical or artificial intelligence methodologies and studies that compare model uncertainties, uses of the probabilistic information, and skill scores.

Sub-Area 10.8/11.3/12.4: Advanced Resource Management – Towards 100% Renewable Electricity (Joint Area)

Sub-Area Chair(s): Marta Victoria Perez, Aarhus University, Denmark
Matt Stone, Australian National University, Australia
Keiichiro Sakurai, AIST, Japan

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Area 12: PV Deployment, Policy and Sustainability

Area Chair: Annick Anctil, Michigan State University, USA
Co-Chairs: Brittany Smith, National Renewable Energy Laboratory, USA
Arnulf Jäger-Waldau, European Commission's Joint Research Centre, Belgium

Sub-Area 12.1: Government, Policy, and Financing
Sub Area 12.2: Social, Economic, and Environmental Sustainability
Sub Area 12.3: Workforce Education and Diversity
Sub-Area 10.8/11.3/12.4: Advanced Resource Management – Towards 100% Renewable Electricity (Joint Area)
Sub-Area 9.6/12.5: Module and System Reliability in the Circular Economy (Joint Area)

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. It represents an extension of the traditional scope of the conference where current concerns and strategies to increase the adoption of PV as a major electricity source will be discussed. Area 12 also serves as the focus point for examining issues related to equity and social impact, both within the PV industry and its application throughout the world. Two joint areas are planned: the first between Areas 10, 11 and 12, which will address challenges towards 100% Renewable Electricity, while the second one, between Areas 9 and 12, will address environmental impact of PV manufacturing and the circular economy.

Note that Area 12 (along with Area 1) will also be participating in a pilot double-blind review program for submitted abstracts. Special submission instructions will be provided on the abstract preparation/author information page as the submission deadline approaches.

Sub-Area 12.1: Government, Policy, and Financing

Sub-Area Chair(s): Izumi Kaizuka, RTS Corporation, Japan
Arnulf Jäger-Waldau, EC JRC, Belgium

This topic focuses on strategies to sustain or accelerate high PV growth rates and rapid cost reductions through government, policy, and financing models that are critical to the success of PV deployment. The installed costs of a PV system declined by more than 50% between 2010 and 2018 and the PV power became the least cost energy in many regions, yet certain market barriers continue to inhibit wide scale PV deployment. This Sub-Area solicits papers that will help conference participants better understand the government, policy, finance considerations that are paramount to overcoming these barriers. We encourage researchers to present international efforts and discuss potential areas for expanded collaboration in this Sub-Area.

Sub Area 12.2: Social, Economic and Environmental Sustainability

Sub-Area Chair(s): Ilke Celik, South Dakota School of Mines and Technology, USA
Keiichi Komoto, MHIR, Japan

This area seeks submissions with a broad, systems-level perspective on the sustainability of PV, throughout the life cycle. Life-cycle assessment (LCA) of current and future PV technologies is of particular interest. Other areas of interest include perspectives on material supply (e.g. improving efficiency of raw material extraction, concerns related to critical or scarce materials), manufacturing (e.g. dematerialization, efficiency gains), usage (e.g. influencing user behaviour, encouraging adoption) and end-of-life (e.g. recycling technologies, toxicity concerns, disposal pathways). Novel approaches and results regarding assessing the environmental impacts of PV are particularly encouraged. Other social sustainability topics are also encouraged, such as energy access for underserved communities, fostering popular acceptance of PV power, or upholding indigenous peoples' rights with regards to PV project development.

Sub Area 12.3: Workforce Education and Diversity

Sub-Area Chair(s): *Yasuhiro Matsumoto, CINVESTAV, Mexico*
John Benner, Stanford University, USA
Stephen Tay, National University of Singapore, Singapore

This topic focuses on original education methods to prepare the workforce for jobs associated with various aspects of photovoltaic research, manufacturing, systems design and deployment, and grid integration. Innovative education methods can include but are not limited to interdisciplinary approaches in education, new teaching methods, online education, and hands-on learning. Papers regarding diversity throughout the PV workforce are strongly encouraged. Examples of diversity topics could include aspects such as recruitment practices, retention strategies, or assessment methods.

Sub-Area 10.8/11.3/12.4: Advanced Resource Management – Towards 100% Renewable Electricity (Joint Area)

Sub-Area Chair(s): *Marta Victoria Perez, Aarhus University, Denmark*
Matt Stone, Australian National University, Australia
Keiichiro Sakurai, AIST, Japan

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Sub-Area 9.6/12.5: Module and System Reliability in the Circular Economy (Joint Area)

Sub-Area Chair(s): *Eszter Vorashazi, IMEC, Belgium*

Developing a circular economy for PV modules, components, and systems becomes increasingly important as deployments continue to grow. One of the biggest challenges for a circular economy is defining and quantifying what we mean by "circularity". This area welcomes papers on how to define, quantify, and measure circularity for PV systems and components. Maximizing component and system useful life is one way to make PV more circular. This sub area encourages papers on how system reliability and resiliency affect circularity, and approaches to extending the useful life such as optimized O&M, repair, refurbishing, repowering, and reuse/resale. Safety and performance testing of repaired or re-sold components and systems are critical and of strong interest. Developing circular supply chains reduces waste at end of life, and it may have significant benefits for a more resilient and diverse supply chain at all stages from initial manufacturing through operations. submissions on reducing the amount of virgin feedstocks, repairable systems/components, use of recycled feedstocks or materials, supply chain resiliency, and backwards compatibility or spare parts are encouraged. End of life management issues including recycling, material recovery, and system reuse.