

2024 PV Reliability Workshop

Welcome to the 2024 Photovoltaic Reliability Workshop!

NREL hosts this annual workshop so that solar technology experts can discuss current and future issues in PV reliability. Longer-lasting PV systems make lower-cost solar electricity and have less impact on the environment, human health, and natural resources.

PVRW offers a combination of oral presentations, panel discussions with vigorous audience participation, and poster presentations. At our workshop, every attendee is a presenter or the sole guest of a presenter.

Chair:

Michael Owen-Bellini

Committee:

Teresa Barnes
Ken Boyce
Jennifer Braid
David Brearly
Evelyn Butler
Kristopher Davis
Michael Deceglie
Chris Deline
Tristan Erion-Lorico
Robert Flottemesch
Andrew Gabor
Peter Hacke
Clifford Hansen
Henry Hieslmair
Will Hobbs
Anubhav Jain
Cara Libby
Mark Mikofski
Gernot Oreski
Jon Previtali
Ingrid Repins
Laura Schelhas
Colin Sillerud
Nick de Vries
Kent Whitfield

AGENDA – Tuesday, 27 February 2024

Check-In / Breakfast: 7:00 am

8:30 am **Session 1: Reliability Implications of U.S.-Based Manufacturing**

Session Chairs: Tristan Erion-Lorico, Ashley Gauling

- Opening remarks from the Chair — Michael Owen-Bellini, [NREL](#)
- US PV manufacturing growth: Quality and reliability challenges — Theresa Jester, [PI Berlin](#)
- Accelerating US solar manufacturing: The road to onshoring a complete value chain — Harsh Galia, [QCells](#)
- Panel Discussion

Break: 10:05 am

10:30 am **Session 2: Current Events 1**

Session Chairs: Teresa Barnes, Marios Theristis

- Let's talk about PV module re-engineering costs — Henry Hieslmair, [DNV](#)
- Challenges and conclusions using NLP on unstructured PV project O&M text logs — Charity Faith Sotero, [kWh Analytics](#)
- A data-based assessment of solar project availability in the United States — Dan Chawla, [Natural Power](#)
- Panel Discussion

Powermark Prize Announcement: 11:50

Lunch: 12:00 pm

Poster Session A: 1:00 pm

2:30 pm **Session 3: Current Events 2**

Session Chairs: Jon Previtali, Norman Jost

- Tracker availability: assessing its energy impact and how to recover it — Nick de Vries and Shreyas Nagarajan, [Silicon Ranch](#)
- Value of verifying large-scale storage system capability through software simulations and HIL — Ray Saka, [IHI Terrasun Solutions](#)
- Performance modelling and yearlong outdoor degradation analysis of a GaAs//Si tandem module — Martin Springer, [NREL](#)
- Panel Discussion

Break: 3:50 pm

4:20 pm **Session 4: Recycling & Circular economy**

Session Chairs: Dirk Jordan, Dennice Roberts

- Don't forget to make it last: circular economy for PV in the Energy Transition — Heather Mirlet, [NREL](#)
- Developing a PV circular economy — Evelyn Butler, [SEIA](#)
- Making solar even more sustainable through circular practices — Pablo Dias, [SolarCycle](#)
- Panel Discussion

Poster Awards: 5:40 pm (Anubhav Jain)

PVRW Mixer: 5:50 pm

Poster Session A – Tuesday, 27 February 2024

Notes: **DuraMAT** posters are indicated with **red** titles. Presenters are indicated in **bold type**.

- 001.** *Mounting matters. Experimental validation of the WhatsCracking app*, **N. Bosco**
- 004.** *Cross-sectional depth profiling of accelerated and field aged backsheet materials*, **E. Palmiotti**, D.C. Miller, J. Kopatz, C. Roberts, B. King, P. Pasmans, C. Thellen, J. Braid
- 007.** *A low-cost direct-reading device for image contrast soiling quantification*, **B. Guo**
- 010.** *Renewing the DuraMAT Data Hub for the next decade*, **R. White**, R. Hurst, N. Wunder, D. Rager
- 013.** *Effect of interface delamination on the performance of perovskite solar cells: FEM analysis*, **H. Kim**, S. Timsina
- 016.** *Linkage between cell cracks, stress testing, and real-world module performance effect of cell cracks on module power loss and degradation: Modern module architectures*, **V. Parikh**
- 019.** *Electroluminescence image analysis of laboratory hail-impacted glass-backsheet and glass-glass photovoltaic modules*, **S.J. DiGregorio**, J.Y. Hartley, J.L. Braid
- 022.** *Assessment of accelerated stress testing data using tensor decomposition methods*, **A. Glaws**, D. Kern
- 025.** *Lifetime prediction and evaluation technology for crystalline silicon solar cell modules*, **K. Tanahashi**, K. Shirasawa, S. Heito, A. Yoshida, N. Itou, T. Tachibana, H. Takato, K. Niira
- 028.** *Innovative O&M strategies to service aging fleets*, **A. Hartzell**, G. Kemper
- 031.** *Enhancing power prediction of photovoltaic systems through dynamic model-based irradiance-to-power conversion*, **B. Li**, X. Chen, A. Jain
- 034.** *Gaining insight into the possible benefits and unknowns around agrivoltaics*, **B. Todt**
- 037.** *Performance and safety of PV modules with extreme microcracking damage*, **T. Karin**, F. Farina, D.M. Delong, D.A. Delong, B. Li, A. Jain
- 040.** *Insights into bifacial photovoltaic module degradation dynamics*, **S. Ovaitt**, D. Kern, D. Jordan, S. Johnston, E. Palmiotti, P. Hacke, C. Deline
- 043.** *How climate and data quality impact photovoltaic performance loss rate estimations*, **M. Theristis**, K. Anderson, J. Ascencio-Vasquez, J.S. Stein
- 046.** *UV-induced power losses in fielded utility n-type Si PV modules*, **E.A. Gaulding**, S.W. Johnston, T.J. Silverman, M.G. Deceglie
- 049.** *Exact IV-curve extraction of damaged PV modules from outdoor EL images*, **P. Kölblin**, L. Stoicescu, M. Reuter
- 052.** *Reliability study on 8 years field-aged PV connectors*, E. Wang, C. Wang, M. Slowinske, C. O'Brien, **L. Ji**
- 055.** *Predicting instability and the effect of wind loading on single-axis trackers*, **E. Young**, W. Arsalane, B. Stanislawski, X. He
- 058.** *Performance of transparent Tedlar® frontsheets for lightweight PV module designs*, **K.R. Choudhury**, S. Chen, O. Fu, M. Demko
- 061.** *Quantitative comparison of backsheet degradation under accelerated laboratory tests with different light sources*, **X. Gu**, Y. Hong
- 064.** *Key performance indicator metrics for solar and wind assets: Can we use NERC reporting to calculate unified KPIs?*, **J. Karas**, P. Nasery, D. Fregosi
- 067.** *Transfer learning for crack detection*, **E. Cooper**, B. Pierce, J. Braid
- 070.** *Investigating a low-current diagnostic metric for assessing photovoltaic module damage*, **R.M. Smith**, D.J. Colvin
- 073.** *When it comes to the useful life of renewables, can 40 be the new 25?*, **T. Romshek**
- 076.** *Approaches and challenges in detecting glass cracking in large solar panels with ultra-thin glass with ML/AI-assisted processing*, **F. Zhang**
- 079.** *Cracked gridline wear-out follows a power law*, **S. Rabade**, T.J. Silverman, N. Bosco

- 082.** *Optimized PV tracking on complex terrain and beyond*, **B.J. Stanislawski**, E. Young, D. Sigler, A. Glaws, B. Knueven
- 085.** *Predicting molecular-scale dynamics and kinetics occurring during encapsulant degradation*, **M.A. Wilson**, J. Braid, M. Chandross, H. Dedmon, J. Kustas
- 088.** *Mechanical load testing to validate FEA for steel-framed PV modules*, **L. Busby Ahsler**, T. Hudson
- 091.** *Silicon module recycling by high power laser*, P.K. Kanaujia, M.O. Bellini, M. Woodhouse, D.L. Young, **M.C. Gupta**
- 094.** *Durability of copper-printed contacts for silicon solar cells*, **T. Druffel**, D. Williams, K. Elmer, E. Yenney, R. Dharmadasa, A. Rohatgi, A. Upadhyaya, V. Upadhyaya, P. Strandins, S. Mitra, S. Johnston, H. Guthrey, P. Hacke
- 097.** *Performance and reliability considerations of bifacial modules on trackers*, R. Chatelain, **T. Deer**
- 100.** *Forensic analysis of solar PV connector field failures*, T. Lolla, W. Li, L. Burnham, B. King, **K. Buch**
- 103.** *Optimizing snow shedding in single-axis tracker photovoltaic systems: A novel approach for enhanced winter efficiency*, **A. Chutani**
- 106.** *Outdoor PID testbed at the Florida Solar Energy Center*, **H. Seigneur**, C. Molto, D. Colvin, R. Smith, P. Hacke, G. Tamizhmani
- 109.** *Experimental and modeling approaches for evaluating and optimizing PID performance in thin film PV technologies*, **K. Patel**, C.A. DiRubio, J. Sharrer, M. Gardeski, D. Guo, B. Clinger, J. Kamiyama, G. Spina, R. Meidanshah
- 112.** *Technoeconomic analysis (TEA) support*, E. Palmiotti, M. Springer, T. Silverman, J. Braid, D. Jordan, C. Deline, **J. Zuboy**, M. Woodhouse, T. Barnes
- 115.** *PV connector reliability and overview of mail-in program*, **B.H. King**, S. DiGregorio, L. Burnham, T. Lolla, W. Li, V. Ramasamy, A. Walker, J. Desai
- 118.** *Multifunctional and durable engineered glass for PV applications*, **J. Carter**, K. Ito, M. Park, V. Zorba
- 121.** *Degradation mechanisms and the role of sequenced accelerated testing to ensure long-term solar module encapsulation*, **K. Liu**, D.C. Miller, N. Bosco, R.H. Dauskardt
- 124.** *PVDeg: development of a streamlined tool for PV degradation modeling*, **M. Kempe**, S. Ovatt, T. Ford, M. Springer
- 127.** *Forecasting glass resilience of large-format photovoltaic modules*, **M. Springer**, T. Silverman, N. Bosco

AGENDA – Wednesday, 28 February 2024

Check-In / Breakfast: 7:00 am

DOE Announcement: 8:30 am

8:40 am **Session 5: Glass & Cell Fracture**
Session Chairs: Michael Deceglie, Sara MacAlpine

- Glass durability and breakage — Michael Pilliod, [Central Tension](#)
- Large-format PV modules: A survey of mechanical breakage statistical data — Colin Sillerud, [CFV](#)
- Hail impact characterization of modules to inform damage mitigation and loss modelling — Peter Bostock, [VDE](#)
- Panel Discussion

Break: 10:00 am

10:30 am **Session 6: Big floppy modules. Special Panel**
Session Chairs: Tim Silverman

- Risk mitigation of large form factor PV modules — Colleen O'Brien, [UL](#)
- Quality and reliability issues in large PV modules — Christos Monokroussos, [TUV Shanghai](#)
- —Will Hobbs, [Southern Company](#)
- Panel Discussion

Lunch: 11:50 am

Poster Session B: 12:50 pm

2:20 pm **Session 7: Cell Issues & Metallization**
Session Chairs: Laura Schelhas, Nicholas Irvin

- Long-term performance and reliability of silicon heterojunction solar modules — Alessandro Virtuani, [CSEM](#)
- UV degradation in PV cells — Archana Sinha, [PVEL](#)
- Metallization reliability — Peter Hacke, [NREL](#)
- Panel Discussion

Break: 3:40 pm

4:10 pm **Session 8: Polymer Issues**
Session Chairs: Xiaohong Gu, Elizabeth Palmiotti

- Sequential stress testing identifies processing defects in bifacial photovoltaic module packaging that limit durability — Soňa Uličná, [NREL](#)
- Analysis of degradation and cracking behaviour of PVDF-based backsheets — Chiara Barretta, [PCCL](#)
- Predictive mechanics and photochemical degradation kinetics modeling for polymeric encapsulants — Kuan Liu, [Stanford University](#)
- Panel Discussion

Poster Awards: 5:30 pm (Anubhav Jain)

Workshop Meetup at Edgewater Public Market: 6:15 pm

Poster Session B – Wednesday, 28 February 2024

Notes: Presenter names are in **bold type**.

- 002.** *Enhancing reliability: Branch connector in a modular outdoor assessment approach for photovoltaic connector testing*, M. Kempe, J. Newkirk, R. Arnold, **A. Jackson**
- 005.** *Performance loss rate in photovoltaic systems*, **M.G. Deceglie**, K. Anderson, D. Fregosi, W.B. Hobbs, M.A. Mikofski, M. Theristis, B.E. Meyers
- 008.** *IEC TC 82 status*, **G. Kelly**
- 011.** *Solar PV joint failure survey results*, **J. Ness**
- 014.** *Comparison of standard backtracking model with actual tracker setpoints*, **A. Parikh**, P. Wolffersdorff
- 017.** *Soiling losses can be 3-11% despite frequent rain in places like the Southeast US*, **W.B. Hobbs**, M. Hendricks, J. Rand, M. Reed
- 020.** *Impact of extreme weather and natural hazards on grid operations: A focus on utility-scale solar*, **S. Awara**, S.C. Dhulipala, N.D. Jackson, T. Gunda
- 023.** *Performance of degradation rate analysis tools for small-scale PV systems under different climatic conditions*, **M.B. Köntopp**, G. Papageorgiou, D. Buss, M. Queck
- 026.** *Unveiling the unseen: harnessing UV fluorescence for comprehensive rooftop PV system assessment and successful insurance claims process*, M. Franks, **C. Kellum**, A. Gabor
- 029.** *Overirradiance unveiled: Understanding, mitigating, and enhancing solar energy performance*, **L.A.Z. Sergio**, A.M. Pires, A.C.d.O. Machado, N.F. Filho, R. Rüter
- 032.** *Surface chemistry characterization of functionalized silica nanoparticle coatings subjected to cementation*, **R.A. Fleming**
- 035.** *Codes & standards gaps - solar PV critical structural connections*, **G. Robinson**, J. Cormican
- 038.** *Fusing insights from natural hazards assessments for grid resilience: A case study of reliable photovoltaics production*, N. Jackson, **T. Gunda**, S. Dhulipala, S. Awara
- 041.** *AC impedance characteristics and modeling of electrical leakage circuit within a photovoltaic module*, **T. Tanahashi**, T. Oozeki
- 044.** *Identifying trends and inaccuracies in US fleet solar metadata*, **K. Perry**, Q. Nguyen, R. White
- 047.** *Cold climate degradation: an analysis of double-axis tracked, E-W vertical, and fixed-tilt photovoltaic deployments in Alaska*, **E. Tonita**, D. Jordan, S. Ovatt, H. Toal, C. Pike, K. Hinzer, C. Deline
- 050.** *stGAE-detect: Leveraging spatio-temporal value dependencies for autonomous PV dataset grading and outlier detection*, **R. Wieser**, Y. Fan, L. Bruckman, Y. Wu, R. French
- 053.** *Completing the feedback loop: Linking data, operations and maintenance, manufacturers, and insurance markets*, **A. Shinn**, C.F. Sotero
- 056.** *Novel AI-powered methods for PV and energy storage asset management software*, **R. van Haaren**
- 059.** *Connector reliability in the US: Part I. A national look at a significant reliability challenge*, **L. Burnham**, B. King, S. DiGregorio, A. Walker, T. Lolla, W. Li, V. Ramasamy, J. Desai
- 062.** *Non-contact EL module inspection using linescan cameras*, **G. Horner**, L. Vasilyev, E. Ignatovich, P. Miller, T. Dirriwachter, K. Lu, J. Williams, E. Schneller, T. Frank, S. Johnston
- 065.** *Optimization of irradiance sensor siting for tree-shaded projects*, **J. Organ**
- 068.** *Inconsistent PV inverter reliability reporting and potential impacts on project financing*, **S. Ressler**
- 071.** *Impact of PV degradation rates through system lifetime*, **B. Hartweg**, S. Montañez, S. Fallon
- 074.** *Analysis of PV module power loss and cell crack effects due to accelerated aging tests and field exposure*, **R. Flottemesch**
- 077.** *Field representative hail strikes in lab environment*, N. Sainbhi, E. Brosz, **M. Bolen**
- 080.** *Cold weather considerations for PV tracker*, **S. Lokanath**

- 083.** *When hail attacks: visible module damage and performance impacts*, **S. MacAlpine**
- 086.** *Encapsulation of perovskite solar cells by vacuum lamination*, **R. Witteck**
- 089.** *Screening of thin film silicon modules for hotspot formation using electroluminescence imaging*, **R. Vasudevan**, G. Mathiazhagan, E. Hamers, K.P. Sreejith, A. Smets
- 092.** *Accelerated stress testing of metal-halide perovskite photovoltaic modules under light and elevated temperatures*, **N.P. Irvin**, M. Owen-Bellini, S. Uličná, T.J. Silverman, J. Schall, D.B. Kern, R. Arnold, K. Terwilliger, M. Deceglie, S. Hayden, X. Shi, C. Fei, J. Huang, J.S. Stein, **L.T. Schelhas**
- 095.** *Statistical downscaling of climate models for solar resource assessment*, **J. Yang**, M. Sengupta, A. Habte, Y. Xie, D. Nychka, M. Bailey, S. Bandyopadhyay
- 098.** *Development and reliability of screen-printable fire-through Cu paste for passivated contact solar cells*, S. Mitra, S. Johnston, H. Guthrey, P. Hacke, R. Dharmadasa, T. Druffel, K. Elmer, A. Nambo, D. Williams, A. Upadhyaya, V.D. Upadhyaya, A. Rohatgi, **P. Stradins**
- 101.** *Enhancing performance of solar trackers through wind nowcasting and aerodynamic mitigations*, M. Elnahla, P. Fatehi, **Y. Guo**, T. Wu, J. Elsworth, S. Dana
- 104.** *Only you (...and your O&M contractor and your equipment manufacturer) can prevent equipment fires: Insights from maintenance logs on thermal events and equipment fires*, **V. Anderson**
- 107.** *Inter-Layer cracking*, **A. Hendricks**, J. Rand, M. Reed, A. Cooper
- 110.** *Enhancing perovskite solar cell stability: A review of current strategies*, **B. Curoe**
- 113.** *Improvement of hail resistance in cover glass for solar panel*, **Y. Kobayashi**, T. Nagasako, K. Imakita, Y. Morishima, M. Ozeki
- 116.** *UV stress testing of perovskite devices packaged with different UV-blocking materials*, **N.D. Trejo**, G. Eperon, B.M. Habersberger, L.S. Madenjian
- 119.** *PV performance and reliability research: a vision on better connecting upstream and downstream data for lifecycle management of PV technologies*, A. van der Heide, N. Kyranaki, **A. Reinders**, W. van Sark, J. Schmitz, O. van der Sluis
- 122.** *A case study of testing prototypes of commercial photovoltaic modules with passive cooling attachment in hot desert climate*, **C. Bainier**, E. Kam-Lum
- 125.** *New public Hail Forensics Database for PV Power Plants and hail defense best practices*, **J. Previtali**, P. Bostock, K. Elser
- 128.** *Reliability at the core of ESS lifecycle costs*, **P. Zoli**

AGENDA – Thursday, 29 February 2024

Check-In / Breakfast: 7:00 am

8:30 am

Session 9: Extreme Weather

Session Chairs: Steve Johnston, Sarah Awara

- Severe thunderstorm hazards and PV: Assessing risk now and in the future — John Allen, [Central Michigan University](#)
- Extreme weather and PV: performance and resilience lessons — Dirk Jordan, [NREL](#)
- Typhoon-ovoltaics: Successes, failures, and lessons learned after a typhoon in Guam and wind events elsewhere — James Elsworth, [NREL](#)
- Panel Discussion

Break: 9:50 am

10:20 am

Session 10: Connectors

Session Chairs: Kenneth P. Boyce, Soňa Uličná

- Photovoltaic cable connectors: A comparative assessment of the present state of the industry — David Miller, [NREL](#)
- NEMA Solar PV Council standardization activity — Jonathan Stewart, [NEMA](#)
- Using robots for inspecting connectors — Derek Chase, [OnSight](#)
- Panel Discussion

Lunch: 11:40 am

Poster Session C: 12:40 pm

2:10 pm

Session 11: Inverters

Session Chairs: Peter Hacke, Chiara Barretta

- PV inverter reliability for emerging power electronics technologies — Akanksha Singh, [DNV](#)
- More inverter troubles: Let's go to 3,000 Volts! — Bill Brooks, [Brooks Engineering](#)
- Device-centric reliability of PV inverters — Sudip K. Mazumder, [University of Chicago](#)
- Enhancing solar PV inverter reliability: A retrofit approach for predictive maintenance — Wayne Li, [EPRI](#)
- Panel Discussion

Break: 3:30 pm

4:00 pm

Session 12: Emerging Technology Panel

Session Chairs: Nick de Vries

- Scale and its importance in 2T perovskite/silicon device and module development — Todd Krajewski, [Swift Solar](#)
- Large-scale perovskite/silicon tandem modules: opportunities and challenges — Charlie Hasselbrink, [Caelux](#)
- TPV: Industry Update on 4T Perovskite - Silicon Tandems — Sean Dunfield, [TandemPV](#)
- Bridge to bankability for perovskite-based modules — Parth Bhatt, [DNV](#)
- Panel Discussion

Poster awards: 5:20 pm (Anubhav Jain)

Poster Session C – Thursday, 29 February 2024

Notes: Presenter names are in **bold type**.

- 003.** *PV inverter availability from the US PV fleet*, **C. Deline**, M. Springer, K. Anderson, R. White, K. Anderson, I. Tse
- 006.** *Creating a universal PV plug and socket standard*, **M. Kempe**
- 009.** *Development of stability tests and accelerated stress tests for perovskite solar cells*, **T. Tayagaki**, K. Yamamoto, T.N. Murakami, M. Yoshita
- 012.** *Environomical design: practical applications and 12-year results of pareto surface optimization for energetic, economic, and environmental objectives*, **L. Diwan**, C. Walinski, A. Tai
- 015.** *Butyl-integrated roof sealing reliability*, **D. McDougall**, P. Fiero, E. vanCampen
- 018.** *Wind damage to a rooftop array at NREL*, B. Sekulic, B. McDanold, J. Parker, A. Walker, D. Jordan, J. Elsworth, E. Hotchkiss, **I. Repins**
- 021.** *Adhesion measurement considerations for bifacial mini modules under accelerated testing*, **D. Roberts**, S. Johnston, K. Terwilliger, S. Uličná, M. Owen-Bellini, L. Schelhas, D. Kern
- 024.** *Introducing the baseline performance reference for irradiance in PV system applications*, **A. Habte**, A. Driesse, M. Sengupta
- 027.** *Reliability for extreme weather: the challenge of climate change*, S. Kumar, L. Wang, **M. Pravettoni**
- 030.** *New capabilities in the National Solar Radiation Data Base (NSRDB)*, M. Sengupta, **Y. Xie**
- 033.** *PV standards activities of IEC*, **J. Wohlgemuth**
- 036.** *Build your own low-cost PV test lab*, **R. Stromberg**
- 039.** *UV fluorescence imaging for solar panel product development and durability testing*, **A.M. Gabor**, D. Miller, I. Gould, M. Owen-Bellini
- 042.** *Direct imaging on electrical conduction degradation of front metal/Si contact in utility scale c-Si modules by nanoelectrical probe*, **C.S. Jiang**, E. Gauding, S. Johnston, M. Deceglie, J. Magum, G. Paul
- 045.** *Large-format modules and legacy assumptions*, **F. Oudheusden**
- 048.** *BIPV long term outdoor study*, **R. Pleydon**
- 051.** *Photovoltaic module performance for six years after hail damage*, **S. Johnston**, K. Terwilliger, R. Wai, D. Kern, D. Jordan
- 054.** *Performance testing of PV cells and modules at NREL*, J. Gallon, J. Brewer, T. Song, J. Geisz, C. Mack, R. Williams, R. Briggs, A. Anderberg, L. Ottoson, D. Friedman, **N. Kopidakis**
- 057.** *Criteria and decision matrix for selecting modern soiling measurement systems*, **J. Horst**
- 060.** *Encapsulants - robust packaging for durable performance*, **L. Madenjian**, J. Munro
- 063.** *Degradation study of organic photovoltaic devices under Brazil's tropical climate conditions*, L.P.Z. de Moraes, M.M. Viana, G.A. Soares, A.S.A. Diniz, **L.L. Kazmerski**
- 066.** *Investigating encapsulant mechanical properties with cross-sectional nano-indentation*, **S. Mitterhofer**, A. Aiello, K. Jensen, X. Gu
- 069.** *Non-contact QE characterization methods*, **K. Lu**
- 072.** *Evaluation of the irradiance term in the ASTM 2848 methodology for capacity testing of utility scale projects*, **P. Metaut**
- 075.** *Novel meteorological and economic hail risk maps for PV*, **D. Weaver**, J. Previtali, P. Bostock
- 078.** *Spatially resolved degradation characterization in photovoltaic components using Raman spectroscopy*, **A. Aiello**, S. Mitterhofer, K. Jensen, C.M. Stafford, S.S. Watson, L.P. Sung, X. Gu
- 081.** *Marsh Severe Hail Model*, **S. Fox**
- 084.** *Development of a rapid screening protocol for unencapsulated silicon PV architectures*, **M.M. Rasmussen**, J.D.Z. Sempertegui, J.G. Gezelter, N.G. Tshuma, M. Kamperai, C.H. Chen, N.

- Moser-Mancewicz, C. Molto, M.I. Bertoni, K.O. Davis, I.T. Martin, L.S. Bruckman
- 087.** *Reducing PV damage from hail, wind-driven debris and sand*, **J. McCabe**
- 090.** *Evaluation of the ASTM and IEC protocols for capacity tests of utility scale projects*, **A. Berlinsky**, P. Metaut, C. Bordonaro
- 093.** *Solar cell crack image generation for power loss prediction*, **N. Jost**, E. Cooper, B. Pierce, J.L. Braid
- 096.** *PV resilience to natural catastrophes: how do resilient site designs impact Nat Cat modeling & ultimately property insurance premiums?*, **N. Thompson**
- 099.** *Accelerated laboratory weathering and material characterization of polypropylene-based backsheets*, **K. Jensen**, S. Mitterhofer, A. Aiello, C. Barretta, G. Oreski, X. Gu
- 102.** *PV vs extreme weather: a summary of major physical loss drivers*, **R. Fagan**
- 105.** *Bringing solar availability assumptions down to Earth: empirical data can guide the industry forward*, **H. Rasmussen**, B. Browne
- 108.** *Identification and mitigation of hail risk in photovoltaic systems*, **A. Dionigi**
- 111.** *Investigating signs of contact degradation in field-exposed silicon photovoltaic modules*, **M. Liggett**, D.J. Colvin, B. Babu, W.C. Oltjen, X. Yu, M. Matam, H.P. Seigneur, M. Li, A.M. Gabor, P.J. Knodle, C.J. Neal, S. Seal, L.S. Bruckman, R.H. French, A. Stoetzer, A. Ballen, D. Riley, B. King, K.O. Davis
- 114.** *PV module moisture ingress modelling*, **M. Vogt**
- 117.** *Post-mortem failure analysis of metal halide perovskite modules*, **S. Uličná**, S.C. Hayden, M. Owen-Bellini, N.Y. Doumon, J. Schall, D.B. Kern, T.J. Silverman, C. Fei, J. Huang, A. Flick, A. Carbone, R. Dauskardt, J.J. Berry, L.T. Schelhas
- 120.** *Research on moisture vulnerability through damp-heat test characteristics for n type-based solar cells*, **Y. Min**, J-h. Choi, T-h. Kim, T-y. Park
- 123.** *Performance and reliability considerations of bifacial modules on trackers*, **T. Deer**
- 126.** *A new solar PV glass quality standard*, **B. Weinschenker**
- 129.** *Portable electroluminescence and photoluminescence imaging setup for mini photovoltaic modules*, **W. Wall**, W. Hobbs, T.J. Silverman, L.T. Schelhas, M. Owen-Bellini

Poster Layout: City Lights Ballroom

All Windows

