

# PV Reliability Workshop – Online

February 22 – 26, 2021



Welcome to the 2021 Photovoltaic Reliability Workshop! This year's workshop continues in the tradition of engaged attendees. Participation requires sharing of a paper—either an oral or poster presentation—by each company at some time during the week. This workshop provides a unique opportunity for group discussions that can yield answers and bring participants to a common understanding for current questions in module and system reliability.

This year we are excited to help everyone stay safe, healthy, AND engaged by holding the workshop online for the first time. The virtual platform allows you to move about the virtual event and mingle with your colleagues. We look forward to “seeing” you there!

## Chair:

Matthew MULLER

## Committee:

Kevin ANDERSON

Rob ANDREWS

Teresa BARNES

Evelyn BUTLER

Yuepeng DENG

Cliff HANSEN

Larry KAZMERSKI

Sarah KURTZ

David MEAKIN

Andreas MEISEL

Jenya MEYDBRAY

Mark MIKOFSKI

Jon PREVITALI

Ingrid REPINS

Tony SAMPLE

Tim SILVERMAN

Josh STEIN

Itai SUEZ

Allan WARD

Karl-Anders WEISS

John WOHLGEMUTH

## AGENDA – Monday, 22 February 2021

**7:30 AM** Online lobby opens at <https://events.eposterboards.com/e/pvrw-2021-lobby/register>. Please come network with your colleagues before the oral session. From the lobby, you can move to the oral sessions or the poster rooms.

**8:00 - 9:15**

**Oral Session 1: Reliability and Field Failures**  
*Session Chairs: Josh Stein (Sandia National Laboratory) Jennifer Braid (Sandia National Laboratory)*

**8:00** – Insights from PV degradation observed in field surveys in India: 2013-2020 -- Narendra Shiradkar (IIT-Bombay)

**8:15** – Reliability overview of aging Italian PV assets – Mark Rossetto (MRP Renewable Energy Solutions)

**8:30** – 35 years of photovoltaics: analysis of the TISO 10 kW solar plant – Eleonora Annigoni (Holland Innovative)

**8:45** – Field accelerated stress testing (FAST): Forecasting plant-specific failure modes and degradation rates – Govindasamy TamizhMani (Arizona State University)

**9:00** – Live Q&A with all speakers

**9:20 - 10:20** Poster Session A: Live interaction with poster presenters and attendees via ePosterBoards. (Posters may viewed in advance at <https://pvrw2021.kontainer.com/direct/5kVbHZ8ksO>.)

**10:20 - 11:50**

**Oral Session 2: Catastrophic Weather and Insurance**  
*Session Chairs: Jon Previtali (Wells Fargo), Simran Raju (DNV•GL)*

**10:20** – Field EL on hundreds of thousands of modules post-storm and -wildfire to support insurance claims – Andrew Sundling (PV Evolution Labs)

**10:35** – Hail risk modeling – Peter Bostock (VDE Americas)

**10:50** – Mature risk strategies for a maturing industry: mitigating the adverse impact of CAT risk underwriting to accelerate PV solar development – Michael Kolodner (Marsh Insurance)

**11:05** – Reinsurer's perspective on PV reliability and CAT exposures – Edward Hsi (Swiss Reinsurance Company)

**11:20** – Re-evaluation of PV hail impact testing: compliance beyond 25 mm – Kent Whitfield (Nextracker) and Cherif Kadir (Renewable Energy Test Center)

**11:35** – Live Q&A and extended panel discussion (overcoming the barrier of extreme premiums or projects that become uneconomical due to catastrophic weather risk)

**11:55 - 12:00** Poster Session A awards (Xiaohong Gu)

**Please note:** All times in the printed agenda are Mountain Times.

## Poster Session A – Monday, 22 February 2021

**Notes:** **DuraMAT** posters are indicated with **red** titles.  
The letter indicates the session, the first number indicates the FLOOR, and the second number indicates the TABLE.

**A-1-1 Janine Denz,**

Application of infrared imaging for quantitative power loss determination in the field

**A-1-2 Yuliya Voronko, Gabriele C Eder, Christian Breitwieser, Wolfgang Mühleisen, Lukas Neumaier, Sonja Feldbacher, Gernot Oreski, Norbert Lenck,**  
Repair options for PV modules with cracked backsheets

**A-1-3 James Elsworth, Otto van Geet,**  
Solar PV storm hardening costs and considerations

**A-1-4 Tucker Farrell, Guangdong Zhu,**  
Unmanned aerial systems for analysis and monitoring of photovoltaic fields

**A-1-5 Andrew M Gabor, Duncan WJ Harwood,**  
Do those short solar cells cracks that I can barely see in EL really matter?

**A-1-6** Networking table

**A-1-7 William B Hobbs, Timothy J Silverman,**  
Low-cost electroluminescence with a Raspberry Pi high-quality camera

**A-1-8 Shu-Tsung Hsu, Wei-You Lin, San-Yu Ting,**  
The analysis of performance and deformation for photovoltaic module by dynamic mechanical loads test under different wind speeds

**A-1-9 Nicole D Jackson, Thushara Gunda, Andrea Staid,**  
Weather impacts on utility-scale photovoltaic plant performance

**A-1-10 Cara Libby,**  
Effect of cell cracks on module power loss and degradation

**A-1-11 Anubhav Jain,**  
Overview of DuraMAT software tool development

**A-1-12 Alae Azouzoute,**  
Developing a cleaning strategy for hybrid solar plants PV/CSP: a case study for semi-arid climates

**A-2-1 Dirk C Jordan, Ingrid Repins, Mike Kempe, John Bleem, Jeff Menard, Paul Davis,**  
Life after 30 years: a PV system in Colorado

**A-2-2 Antonia Sonia AC Diniz, Suellen CS Costa, Dênio A Cassini, Daniel S Braga, Tulio Duarte, Jorge AP Rodrigues, Neolmar de M Filho, Vinicius C Santana, Lucas Phillip ZG de Moraes, Bernardo Guimarães, Lawrence L Kazmerski,**  
PV reliability R&D at GREEN PUC Minas, Brazil: a synopsis

**A-2-3 Claire Kearns-McCoy, James Nagel,**  
Use of electroluminescence imaging to detect module installation damage

**A-2-4 Bruce King, Joshua Stein, Ashley Maes, William Snyder, Karen Yang,**  
DuraMAT fielded module study

**A-2-5 Teh Lai, BG Potter, Jr., Kelly Simmons-Potter,**  
Analysis of PV module aging using electroluminescence imaging

**A-2-6 Ian Marius Peters,**  
Module reliability and value-of-electricity metrics

**A-2-7 Nathan Stang, Jon Ness, Todd Letcher,**  
Loosening of aluminum PV racking bolted joints due to relaxation

**A-2-8 Raymond J Wieser, Stephanie L Moffitt, Evan Boucher, Ruben Zabalza, Xiaohong Gu, Colleen O'Brien, Liang Ji, Adam W. Hauser, Greg S O'Brien, Roger H French, Michael D Kempe, Jared Tracy, Kaushik R Choudhury, Laura S Bruckman, Kenneth Boyce,**  
A statistically-informed field survey protocol: application on 10 PV sites

**A-2-9 Ethan Young,**  
Computational methods to characterize panel loading conditions for accelerated testing

**A-2-10 Nicola Sicchieri, Soňa Uličná, Rachael L. Arnold, Bruce King, Ashley Maes, David C. Miller, Jimmy M. Newkirk, Laura T. Schelhas, Archana Sinha, Kent Terwilliger, Michael Thuis, Nicoleta Voicu, Kurt van Durme,**  
BACKFLIP: Determination of backsheets material properties

**A-2-11 Michelle McCann, Lawrence McIntosh, Gabe Nelson, Alana Cameron**  
Impact of hail damage on different photovoltaic panel types

**A-2-12 Kamel Agouri,**  
Optical and thermal analysis of a new EVA as encapsulant material in the photovoltaic market



## AGENDA – Tuesday, 23 February 2021

7:30 AM	Online lobby opens at <a href="https://events.eposterboards.com/e/pvrw-2021-lobby/register">https://events.eposterboards.com/e/pvrw-2021-lobby/register</a> . Please come network with your colleagues before the oral session. From the lobby, you can move to the oral sessions or the poster rooms.
8:00 - 9:15	<b>Oral Session 3: Field Degradation</b> <i>Session Chairs: Dirk Jordan (NREL), Mario Theristis (Sandia National Laboratory)</i> <b>8:00</b> – Degradation analysis of crystalline silicon photovoltaic modules exposed to typical climates in China -- Huili Han (Xin Yang Normal University) <b>8:15</b> – A practical summary of PV module field degradation and failure – Kristine Sinclair (DNV•GL) <b>8:30</b> – PV fleet performance data initiative: 2021 update– Chris Deline (NREL) <b>8:45</b> – Long-term stability and field degradation data for PERC-type modules – Max Köentopp (Hanwah Q-Cells) <b>9:00</b> – Live Q&A with all speakers
9:20 - 10:20	Poster Session B: Live interaction with poster presenters and attendees via ePosterBoards. (Posters may viewed in advance at <a href="https://pvrw2021.kontainer.com/direct/5kVbHZ8ksO">https://pvrw2021.kontainer.com/direct/5kVbHZ8ksO</a> .)
10:20 - 11:35	<b>Oral Session 4: Inverters and Power Electronics</b> <i>Session Chairs: Chris Deline (NREL), Devin Hawkins (Chint Power)</i> <b>10:20</b> – Inverter testing: recent results and findings – Jenya Meydbray (PV Evolution Labs) <b>10:35</b> – Progress toward predictive maintenance of solar plants – Dana Olson (DNV•GL) <b>10:50</b> – Firming up solar: battery considerations for utility-scale PV plus storage projects– Ron DiFelice (Southern Current) <b>11:05</b> – 62093 BOS and inverter qualification test – Peter Hacke (NREL) <b>11:20</b> – Live Q&A
11:40 - 11:45	Poster Session B awards (Xiaohong Gu)

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**Poster Session B – Tuesday, 23 February 2021 (DuraMAT posters are indicated with red titles.)**

**Notes:** **DuraMAT** posters are indicated with red titles.  
The letter indicates the session, the first number indicates the FLOOR, and the second number indicates the TABLE.

**B-1-1 Teresa M. Barnes**, Margaret Gordon, Laura Schelhas,

DuraMAT: Leveraging field data, advanced characterization, multi-scale modeling, accelerated testing, and material development to improve module reliability

**B-1-2 Sara Bouguerra**, Kamel Agroui, Mohamed Rédha Yaiche, Ismail Kaaya, Djamel Eddine Mansour,

Degradation rate for encapsulant browning in Algeria region for different PV module orientations

**B-1-3 Claudia Buerhop**, Oleksandr Stroyuk, Tobias Pickel, Marius Peters, Jens Hauch,

The impact of the backsheet material on the performance of PV-systems

**B-1-4 William Gambogi**, Sara MacMaster, B-L Yu, K Roy Choudhury, Peter Hacke, Kent Terwillinger,

Encapsulant and backsheet impact on PID resistance of bifacial pPERC modules

**B-1-5 Da Guo**, Sam Demtsu, Igor Sankin, Jose Alonzo Calderon, Markus Gloeckler,

Degradation kinetics and modeling of CdTe solar cells based on *in-situ* IV measurements

**B-1-6 Yunfeng Yang, Brian Habersberger**,  
Elucidating the role and origin of ions in PID on bifacial p-PERC cells

**B-1-7 Clifford Hansen**, Dirk Jordan, Michael Deceglie, Thushara Gunda, Hector Mendoza, Matt Muller, William Vining,

Data cleaning for degradation analyses

**B-1-8 James Hartley**, Scott Roberts, Michael Owen-Bellini, Peter Hacke,

DuraMAT: An integrated, multi-physics, multi-scale modeling capability for PV stressors and failures

**B-1-9** Networking table

**B-1-10 Stephanie L Moffitt**, Behrang H Hamadani, Xiaohong Gu,

Investigating the effect of voltage bias and damp heat on sodium movement within solar panel encapsulants

**B-1-11 Paul Ndione**, Daniel J Friedman, Nikos Kopidakis,

Ultra-fast spectral response measurement of full-size photovoltaic modules

**B-1-12** Networking table.

**B-2-1 Neil Ramchandani**, Paul Boman,  
Dissolved gas analysis for solar PV plant transformers

**B-2-2 William Sekulic**, Chris Deline, Byron McDanold, Josh Parker, Kandler Smith,  
Battery storage durability and aging testing at National Renewable Energy Laboratory, Golden, CO

**B-2-3 Eivind B Sveen**, Mari B Øgaard, Josefine H Selj, Gaute Otnes,  
PV system degradation rates in the Nordics

**B-2-4 Marios Theristis**, Julián Ascencio-Vásquez, Joshua S Stein,  
Geographic and technology factors in photovoltaic performance degradation rate estimations

**B-2-5 Andy Walker**, Jal Desai, Alexandra Aznar, Nichole Liebov, Gerald Robinson,  
DOE FEMP PV system performance assessment

**B-2-6 Thomas Weber**, Simon Koch, Nithin Murali, Steven Xuereb, Paul Grunow,  
Latest PID results: current module types affected by both negative and positive system voltage

**B-2-7 Robert White**, Courtney Pailing, Nalinrat Guba, Nick Wunder, David Rager, Chris Webber,  
DuraMAT Data Hub: Year 5 status and activities

**B-2-8 Samantha Wilson**, Steve Lightfoote, Nathan Zorndorf, Ahmed Slaoui, Steve Voss,  
Filtering anomalous performance data to curate event free intervals

**B-2-9 Michael Woodhouse**, Brittany Smith,  
Technoeconomic analysis support to DuraMAT

**B-2-10 E Victor Garcia**, Adam B Shinn,  
Industry-average system level degradation is potentially double the most frequent financial model assumption

**B-2-11 Jens Moschner**, F Poormohammadi, J Despeghe, S Ravyts, J Driesen,  
Impact of power limitation on inverter temperature and efficiency

## AGENDA – Wednesday, 24 February 2021

7:30 AM	Online lobby opens at <a href="https://events.eposterboards.com/e/pvrw-2021-lobby/register">https://events.eposterboards.com/e/pvrw-2021-lobby/register</a> . Please come network with your colleagues before the oral session. From the lobby, you can move to the oral sessions or the poster rooms.
8:00 - 9:15	<p><b>Oral Session 5: Emerging Technologies</b>  <i>Session Chairs: Itai Suez (Silfab Solar), Oliver Zhao (Stanford University)</i></p> <p><b>8:00</b> – Research progress on the performance and reliability of high-power Vertex modules– Pierre Verlinden (Trina Solar)</p> <p><b>8:15</b> – Overview of DuraMAT software tool development – Anubhav Jain (Lawrence Berkeley National Laboratory)</p> <p><b>8:30</b> – Reliability PERC modules using Ga-doped <i>p</i>-type mono wafers – Hongbin Fang (Longi Solar)</p> <p><b>8:45</b> – Live Q&amp;A with all speakers</p> <p><b>9:00</b> – Five-minute break to reset the online platform and seat the panelists</p> <p><b>9:05</b> – Panel Discussion: Perovskites on the horizon, stability protocols and reliability – Tim Silverman (NREL), Matt Norton and Maria Hadjipanayi (University of Cyprus), David Bushnell and/or Laura Miranda-Perez (OxfordPV), César Ramirez Quiroz (Nice Solar Energy)</p>
9:20 - 10:20	Poster Session C: Live interaction with poster presenters and attendees via ePosterBoards. (Posters may viewed in advance at <a href="https://pvrw2021.kontainer.com/direct/5kVbHZ8ksO">https://pvrw2021.kontainer.com/direct/5kVbHZ8ksO</a> .)
10:15 - 11:50	<p><b>Oral Session 6: Systems Field Data and Modeling</b>  <i>Session Chairs: Bill Marion (NREL), Kevin Anderson (NREL)</i></p> <p><b>10:20</b> – PV power plant production estimate re-forecasting – Bodo Littmann (VDE Americas)</p> <p><b>10:35</b> – Module field data, modeling, and accelerated testing – Cara Libby (Electric Power Research Institute)</p> <p><b>10:50</b> – Performance loss rates of floating PV systems in the tropics – Abhishek Kumar (National University of Singapore)</p> <p><b>11:05</b> – Bifacial HAST update – Cherif Kedir (Renewable Energy Test Center)</p> <p><b>11:10</b> – Short bifacial field update – Cherif Kedir (Renewable Energy Test Center)</p> <p><b>11:25</b> – Short bifacial field update – Silvana Ayala (NREL)</p> <p><b>11:30</b> – Short bifacial field update – Tristan Erion-Lorico (PV Evolution Labs)</p> <p><b>11:35</b> – Live Q&amp;A with all speakers</p>
11:55 - 12:00	Poster Session C awards (Xiaohong Gu)

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## Poster Session C – Wednesday, 24 February 2021

**Notes:** **DuraMAT** posters are indicated with **red** titles.  
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**C-1-1 Kevin Anderson, Johan Kemnitz,**  
Evaluating various cell temperature models for use in PV system capacity testing

**C-1-2 Alex Berlinsky, Mark Reusser, Shantanu Vaishnav,**  
Modeling sub-hourly clipping losses using available irradiance and power data

**C-1-3 Christine Bordonaro,**  
A study of sub-hourly clipping losses for various solar PV plant designs across the United States

**C-1-4 David Bowersox,**  
Analysis of clipping losses captured through the use of sub-hourly meteorological datasets

**C-1-5 Jessica Forbess, Teff Reed, Rhonda Bailey,**  
Daily soiling rates correlated with precipitation and air quality in Oakland CA

**C-1-6 Ian Gregory, David Prince, Ed Hurley,**  
Benefits and risks of ultra-large panels

**C-1-7 Bill Marion, Byron McDonald, Josh Parker,**  
Use of a baffle for limited-extent albedometer measurements

**C-1-8 Abigail Meyer, P Craig Taylor, Vincenzo LaSalvia, Matthew Page, David Young, Paul Stradins, Sumit Agarwal,**  
Electron paramagnetic resonance investigation of light- and elevated-temperature-induced degradation defects in Ga-doped Czochralski silicon

**C-1-9 Bennet E Meyers, Elsa Kam-Lum,**  
Preliminary application of PVInsight automated machine learning for soiling detection in desert climates

**C-1-10 Mark Mikofski,**  
Comparison of P50 and P90 PV performance between historical TMY and 20 years of SURFRAD measurements

**C-1-11 Shaun Montminy,**  
Delivering on the promise of bifacial

**C-1-12 Abdellatif Bouichi, Zakaria Naimi, Aumeur El Amrani,**

Toward the development of a desert PV module: modeling and analysis of performance and stability

**C-2-1 Jeff Organ, Alex Kapetanovic, Haley DiGiovanni,**  
Quantifying hourly calculation risk to p50 energy forecasting using sub-hourly satellite and ground data

**C-2-2 Diane Palmer, Richard Blanchard,**  
Selection of satellite-derived high-resolution solar radiation datasets for PV performance simulation in East Africa

**C-2-3 Kirsten Perry, Matthew Muller, Kevin Anderson,**  
Detecting clipping periods in AC power time series: comparing machine learning and logic-based techniques

**C-2-4 Stephen Ressler, Todd Tolliver, Dave Doerner,**  
Impacts of large format modules on PV system design

**C-2-5 Sarah E Smith, Andrew Glick, Brooke J Stanislawski, J Stu McNeal, Naseem Ali, Juliaan Bossuyt, Marc Calaf, Raúl Bayoán Cal,**  
Influence of spatial arrangement on heat transfer effects for large-scale solar arrays

**C-2-6 Brooke Stanislawski, T. Harman, Sarah E Smith, Raúl Bayoán Cal, Marc Calaf,**  
The influence of row spacing on convective cooling and performance of solar farms

**C-2-7 Patrick Thornton, Oliver Zhao, Ziyi Pan, Jared Tracy, Kaushik Roy-Choudhury, Paul Roraff, Michael Mooney, Archana Sinha, Laura T Schelhas, Mihail Bora, Reinhold Dauskardt,**  
**Advancing bifacial solar module reliability and manufacturability with new module materials and lightweight transparent back lamination: Thrust 1 adhesive degradation pathways**

**C-2-8 Sarah Toth, Michael Hannigan, Marina Vance, Michael Deceglie,**  
Gridding LA air quality measurements to model PV soiling

**C-2-9 Harrison Wilterdink, Ron Sinton, Adrienne Blum, Karoline Dapprich,**  
Power loss analysis for silicon PV cells and modules using the Richter recombination limit

**C-2-10 Oliver Zhao, Ziyi Pan, Jared Tracy, Kaushik Roy-Choudhury, Paul Roraff, Michael Mooney, Archana Sinha, Laura T. Schelhas, Mihail Bora, Reinhold Dauskardt,**  
**Advancing bifacial solar module reliability and manufacturability with new module materials and light-weight transparent back lamination: Thrust 2 moisture barriers and encapsulation**

**C-2-11 Tushar Shimpi,**  
Optimization of process parameters of spray-coated anti-soiling films for potential application in PV modules



## AGENDA – Thursday, 25 February 2021

7:30 AM	Online lobby opens at <a href="https://events.eposterboards.com/e/pvrw-2021-lobby/register">https://events.eposterboards.com/e/pvrw-2021-lobby/register</a> . Please come network with your colleagues before the oral session. From the lobby, you can move to the oral sessions or the poster rooms.
8:00 - 9:15	<b>Oral Session 7: Standards and Accelerated Testing</b> <i>Session Chairs: Ingrid Repins (NREL), Daniel Zirzow (CFV Labs)</i> <b>8:00</b> – PVQAT update – Tadanori Tanahashi (AIST) <b>8:15</b> – Materials characterization, accelerated testing, and constitutive modeling of electrically-conductive adhesives – Martin Springer (NREL) <b>8:30</b> – IEC-63209-2: Extended stress testing of photovoltaic modules: component materials and packaging – Nancy Phillips (DuPont) <b>8:45</b> – Sequential multi-factor stress testing for backsheet durability evaluation – Mike Kempe (NREL) <b>9:00</b> – Live Q&A with all speakers
9:20 - 10:20	Poster Session D: Live interaction with poster presenters and attendees via ePosterBoards. (Posters may viewed in advance at <a href="https://pvrw2021.kontainer.com/direct/5kVbHZ8ksO">https://pvrw2021.kontainer.com/direct/5kVbHZ8ksO</a> .)
10:20 - 11:35	<b>Oral Session 8: Quality, Reliability and Failures</b> <i>Session Chairs: Michael Deceglie (NREL), Kirsten Perry (NREL)</i> <b>10:20</b> – Fielded module reliability – Rob Andrews (Heliolytics) <b>10:35</b> – Trends in testing PV modules across different technologies and manufacturers – Jenya Meydbray (PV Evolution Labs) <b>10:50</b> – Navigating the warranty process for failed modules – Mike Loeser (Strata Solar) <b>11:05</b> – Quality management best practice guidelines – Ralph Gottschalg (Fraunhofer CSP) <b>11:20</b> – Live Q&A with all speakers
11:40 - 11:45	Poster Session D awards (Xiaohong Gu)

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## Poster Session D – Thursday, 25 February 2021

**Notes:** **DuraMAT** posters are indicated with **red** titles.  
The letter indicates the session, the first number indicates the FLOOR, and the second number indicates the TABLE.

**D-1-1 Mohamed Adawi, Robert A Fleming,**  
Design of an instrumented soiling chamber to evaluate solar PV coatings

**D-1-2 Rodrigo del Prado Santamaria, Gisele A dos Reis Benatto, Adrian A Santamaria Lancia, Martin Garaj, Sune Thorsteinsson, Peter B Poulsen, Sergiu V Spataru,**  
Characterization of electrical parameters of cracked monocrystalline silicon solar cells in photovoltaic modules

**D-1-3 Joshua S Stein, Jennifer L Braid, Charles D Robinson, Duncan Harwood,**  
**Measurement of PV cell crack characteristics in PV modules using digital image correlation**

**D-1-4 Dominika Chudy,**  
Definition of new standard design qualification of hybrid Si/III-V and translucent planar micro-tracking modules

**D-1-5 Hamsini Gopalakrishna, GovindaSamy TamizhMani,**  
Accelerated UV exposure: influence of humidity and backsheets type on encapsulant browning

**D-1-6 LaKesha Perry, Soshana Smith, Stephanie Watson, Shih-Jia Shen, Stephanie Moffitt, Debbie Jacobs, Li-Piin Sung, Xiaohong Gu,**  
Material characterization and durability of transparent backsheets for bifacial PV modules

**D-1-7 Ken Boyce, Colleen O'Brien, Alex Di Sciullo Jones, Scott Jezewski, Liang Ji,**  
UL PV rack and tracker corrosion task group and its progress update

**D-1-8 Todd Karin, Anubhav Jain,**  
**Optical characterization of anti-reflection coatings with off-the-shelf RGB cameras**

**D-1-9 George Kelly,**  
TC 82 status report

**D-1-10 Hansung Kim, Albert Garcia, Ayoub Ifkerne,**  
Degradation of semi-flexible CIGS solar cells due to a bending

**D-1-11 Roger R Hill,**  
New IEC standards on PV availability and reliability

**D-1-12** Networking table

**D-2-1 Geoffrey S. Kinsey,**  
Solar cell efficiencies under operating spectra

**D-2-2 Sarah Kurtz, George Kelly,**  
IEC TS 63209-1: An IEC extended-stress test - results of DTS

**D-2-3 Ingrid L Repins,**  
An update on the new edition of IEC 61215

**D-2-4 Archana Sinha, Katherine Hurst, Soňa Uličná, Laura T Schelhas, David C Miller, Peter Hacke,**  
**PV module-level solutions for degradation by ionization damage**

**D-2-5 Hubert Seigneur, Hossein Ebrahimi, Andrew Gabor,**  
The role of material properties and geometries in microcrack formation in silicon solar cells during cold temperatures

**D-2-6 Colin Sillerud, Daniel Zirzow, Jim Crimmins,**  
Novel sequential testing produces field-like backsheets cracks in known-bad and unknown-bad samples

**D-2-7 Timothy J. Silverman,**  
Partial shade endurance testing of monolithic thin-film modules: IEC TS 63140 is now available

**D-2-8 Ian Slauch, Saurabh Vishwakarma, Rico Meier, Farhan Rahman, Rishi Kumar, Jared Tracy, William Gambogi, James Hartley, David Henning, Mariana Bertoni,**  
**In-situ mapping of deformation in crystalline Si modules: understanding the effects of viscoelasticity**

**D-2-9 Liang Ji, Kent Whitfield, Jon Ness, George Kelly, Alex Di Sciullo Jones, Andrew Pfeifer, Armin Hadzidedic, Chris McIntosh, Colleen O'Brien, Darius Kaunas, Jim Soma, Zennia Villanueva, Mark Schlichting, James Cormican,**  
Fastener corrosion testing

**D-2-10 John Wohlgemuth,**  
PV standards activities of the IEC

**D-2-11 Evelyn Butler,**  
Circular economy activities by the Solar Energy Industries Association

## AGENDA – Friday, 26 February 2021

7:30 AM	Online lobby opens at <a href="https://events.eposterboards.com/e/pvrw-2021-lobby/register">https://events.eposterboards.com/e/pvrw-2021-lobby/register</a> . Please come network with your colleagues before the oral session. From the lobby, you can move to the oral sessions or the poster rooms.
8:00 - 9:15	<b>Oral Session 9: Emerging Technologies Session B</b> <i>Session Chairs: Nick Bosco (NREL), Kristine Sinclair (DNV•GL)</i> <b>8:00</b> – Reliability of low temperature solder for multiwire interconnects -- Laura Spinella (NREL) <b>8:15</b> – Reliability of high-density 'gapless' module designs – Stefan Wendlandt (PI-Berlin) <b>8:30</b> – Interface degradation in glass/glass PV Modules – DuraMAT, Dana Sulas-Kern (NREL) <b>8:45</b> – Combined accelerated stress testing and acceleration factor determination -- Peter Hacke (NREL) <b>9:00</b> – Live Q&A with all speakers
9:20 - 10:20	Poster Session E: Live interaction with poster presenters and attendees via ePosterBoards. (Posters may viewed in advance at <a href="https://pvrw2021.kontainer.com/direct/5kVbHZ8ksO">https://pvrw2021.kontainer.com/direct/5kVbHZ8ksO</a> .)
10:20 - 11:50	<b>Oral Session 10: PV Useful Service Life Prediction</b> <i>Session Chairs: Timothy Silverman (NREL), MinWah Leung (DNV•GL)</i> <b>10:20</b> – Durability considerations outside photovoltaics – Christopher White (Exponent) <b>10:35</b> – Assessing material and module degradation from UV-ionization damage – DuraMAT Archana Sinha (SLAC National Accelerator Laboratory) <b>10:50</b> – Assessing the useful life of PV modules – Henry Hieslmair (DNV•GL) <b>11:05</b> – Experience with repowering – Robert Pharris (Longroad Energy) <b>11:20</b> – Live Q&A all speakers <b>11:35</b> – Five-minute break to reset the online platform and seat the panelists <b>11:40</b> – Panel discussion – The challenges and possibilities for a 50-year module (session speakers, Teresa Barnes (NREL), Charlie Gay (Violet Power), Henry Hieslmair (DNV•GL), Jenya Meydbray (PVEL), Jon Previtali (Wells Fargo)
11:55 - 12:00	Poster Session E awards (Xiaohong Gu)

**Please note:** All times in the printed agenda are Mountain Times.



## Poster Session E – Friday, 26 February 2021

**Notes:** **DuraMAT** posters are indicated with **red** titles.  
The letter indicates the session, the first number indicates the FLOOR, and the second number indicates the TABLE.

**E-1-1 Chiara Barretta, Gernot Oreski, Sonja Feldbacher, Katharina Resch-Fauster, Roberto Pantani,**

Performances of polyolefin-based encapsulants upon the exposure to artificial ageing tests and comparison to ethylene vinyl acetate

**E-1-2 Nick Bosco, Martin Springer, Jiqi Liu, Sameera Nalin Venkat, Roger H French, Timothy J Silverman,**

Representative modules for accelerated thermal cycling and static load testing

**E-1-3 Andre Chavez, Brian Rummel, Nicolas Dowdy, Sang M. Han, Nick Bosco, Brian Rounsaville, and Ajeet Rohatgi,**

Optimization of carbon-nanotube-reinforced composite gridlines towards commercialization

**E-1-4 Alan J Curran, Shiyi Qin, Carolina Whitaker, Thomas Moran, Bryan D Huey, Dylan Colvin, Nafis Iqbal, Kris O Davis, Brent Brownell, Ben Yu, Jean-Nicolas Jaubert, Jennifer L Braid, Laura S Bruckman, Roger H French,**

Degradation of PERC and Al-BSF cells with UV cutoff and white variants of EVA and POE encapsulant

**E-1-5 Michael G Deceglie, Timothy J Silverman, Steve W Johnston, James A Rand, Mason J Reed, Robert Flottemesch, Ingrid L Repins,**

Light and elevated temperature-induced degradation (LeTID) in a utility-scale photovoltaic system

**E-1-6 Sam Ellis, Tushar Shimpi, Larry Maple, Walajabad Sampath, Kurt Barth,**

Progression of a new module architecture and streamlined approach to encapsulation to lower manufacturing cost and improve reliability

**E-1-7 E Ashley Gauling, Michael G Deceglie, Timothy J Silverman, Steve W Johnston, Dana Sulas-Kern, Helio Moutinho, Ingrid L Repins,**  
Differences in printed contacts leads to susceptibility of silicon cells to series resistance degradation

**E-1-8 Peter Hacke,**

Application of acceleration science and validation for combined-accelerated stress test development

**E-1-9 Steve Johnston, Chuanxiao Xiao, Chun-Sheng Jiang, E Ashley Gauling, Michael G Deceglie, Harvey Guthrey, Dana Kern, Mowafak Al-Jassim, Ingrid L Repins,**

LeTID cells from a utility-scale photovoltaic system characterized by deep level transient spectroscopy

**E-1-10 Joseph Karas, Ingrid Repins, Max B Koentopp, Friederike Kersten, Jean-Nicolas Jaubert, Daqi Zhang, Fangdan Jiang, Christos Monokroussos, Lukas Jakisch, Mauro Pravettoni, Stefan Wendlandt, Mauro Caccivio, Giovanni Bellenda, AK Tripathi, et al.,**

Summary of findings from the International Round Robin Study on Light and Elevated Temperature Induced Degradation (LeTID)

**E-1-11 Sherif A Khalifa, Benjamin V Mastrorocco, Dylan D Au, Teresa M Barnes, Alberta C Carpenter, Jason B Baxter,**

The role of reliability in material life cycle waste minimization in silicon photovoltaic systems

**E-1-12 Todd Karin, Anubhav Jain, Bruce King, Michael Deceglie, Bennet Meyers, Dirk Jordan,**

PVPRO: Focus on preprocessing methods

**E-2-1 Marcel Kühne,** PET degradation based on environmental conditions (temperature and humidity)

**E-2-2 Vincent Lami, Ulf Berger, Susanne Müller, Simon Fischer, Martin Hermenau,** On the verge of OPV commercialization

**E-2-3 Jiqi Liu, Sameera Nalin Venkat, Hein Htet Aung, Jakob Wegmueller, Brian Gould, Jennifer L Braid, Ben Yu, Brent Brownell, Xinjun Li, Jean-Nicolas Jaubert, William J Gambogi, Jennifer LW Cater, Laura S Bruckman, Roger H French,** Degradation of monofacial PERC modules with multiple packaging combinations under accelerated exposures

**E-2-4 Imran Khan, Caleb Phillips, Steve Robbins, Robert White, John Perkins, David C Miller,**

Development of a high-throughput optical mapping instrument for accelerated stress testing of PV module materials

**E-2-5 Hoi Ng, Magnolia Pak, Samantha Hoang, Tamir Lance, David Okawa, Michael Kempe, Peter Hacke,**

Advanced material development to support low-LCOE 25-year flexible photovoltaic modules

**E-2-6 Gernot Oreski, Gabriele Eder, Yuliya Voronko, Antonia Omazic, Lukas Neumaier, Wolfgang Mühleisen, Gustaf Ujvari, Rita Ebner, Michael Edler,**

Performance and reliability of co-extruded polypropylene backsheets in PV modules

**E-2-7** Dana B Sulas-Kern, Michael Owen-Bellini, Paul Ndione, Archana Sinha, Soňa Uličná, **Laura Spinella**, Steve Johnston, Michael Owen-Bellini, Laura T Schelhas,  
DuraMAT - Investigation of interfacial degradation in glass/glass PV modules

**E-2-8 Taeko Semba**, Atsushi Masuda,  
The corrosion of the metallization containing PbO SiO<sub>2</sub>-TeO<sub>2</sub> glass frits in c-Si PV modules

**E-2-9 Soňa Uličná**, Archana Sinha, Martin Springer, David C Miller, Peter Hacke, Laura T Schelhas and Michael Owen-Bellini,  
DuraMAT - Failure analysis of an improved polyamide-based, fluoropolymer-free backsheet after combined-accelerated stress testing

**E-2-10 Chuanxiao Xiao**, Chun-Sheng Jiang, Ashley Gaulding, Michael G Deceglie, Dana Sulas-Kern, Mowafak Al-Jassim, Steve Johnston, Ingrid L Repins,  
Junction characterization of LeTID cells from utility-scale photovoltaic system by Kelvin probe force microscopy

**E-2-11 Martin Springer**, Nick Bosco,  
Characterization of the electrical conductivity of ECAs and its dependence on the viscoelastic material response

**E-2-12 Xiaohong Gu**, Yadong Lyu, Michael D Kempe, Thomas Felder,  
Erosion of PV backsheets under UV light and water spray