

# NREL Photovoltaic Reliability Workshop—Golden, Colorado

February 24–27, 2015



## Agenda for Wednesday, February 25, 2015

International PV Quality Assurance Task Force (PVQAT) Workshop

This day will be an extension of the PVMRW, but with a focus on the two IEC work items for climate-specific rating and manufacturing quality management. The morning will include technical presentations that show the progress of PVQAT and shed new light on the most important outstanding technical issues for completing these two work items, with opportunity for discussion. The afternoon will provide an opportunity for breakout sessions, allowing each Task Group time for individual discussion.

The intent of the breakout session is to collect the voices of participants from various areas to determine the remaining issues for effective IEC standards development on the two work items, as well as their future perspectives.

### Chairs

Tony Sample  
Masaaki Yamamichi

### Committee

Govind Ramu  
Sarah Kurtz  
John Wohlgemuth  
George Kelly

## AGENDA Wednesday, February 25, 2015

<b>7:30–8 a.m.</b>	Continental Breakfast
<b>8–8:30 a.m.</b>	<b>Welcome and Plenary Session</b> —Tony Sample (Chair), JRC Overview of PVQAT: Update and Perspectives—Sarah Kurtz, NREL
<b>8:30–9:45 a.m.</b>	<b>Quality Management System</b> —Masaaki Yamamichi, AIST and Yoshihito Eguchi, Mitsui Chemicals (Chairs) <b>8:30</b> - Overview of IEC TS62941 Guideline for Manufacturing QA—Govind Ramu, SunPower <b>8:50</b> - An Independent Auditor's View on Manufacturing QMS—Ian Gregory, SolarBuyer <b>9:10</b> - Manufacturers' Point of View on Manufacturing QA—Xiaowu Yang, Trina Solar <b>9:30</b> - Open Discussion
<b>9:45–10:15 a.m.</b>	<b>Coffee Break</b>
<b>10:15 a.m.– 12 p.m.</b>	<b>Climate-Specific Rating</b> —Tony Sample (Chair), JRC <b>10:15</b> - Overview of IEC82/766/NP 62892-1 Climate-Specific Test—John Wohlgemuth, NREL <b>10:35</b> - Update of PVQAT Task Groups—TG leaders <ul style="list-style-type: none"> <li>• TG1 Govind Ramu (SunPower)      • TG2 Nick Bosco (NREL)      • TG3 John Wohlgemuth (NREL)</li> <li>• TG4 Vivek Gade (Jabil)      • TG5 David Miller (NREL)      • TG12 Mike Van Iseghem (EDF)</li> </ul> <b>11:20</b> - Connecting the dots: Collaborating from factory to field to reduce long-term module quality risk for specific project locations —Jonathan M. Previtali, Wells Fargo Bank <b>11:40</b> - Open Discussion
<b>12–1:30 p.m.</b>	<b>Lunch and Poster Viewing</b>
<b>1:30–3:30 p.m.</b>	<b>Breakout Session</b> <b>1:30–1:40</b> - Orientation for the Breakout Session—Masaaki Yamamichi <b>1:40–3:30</b> - Breakout Discussion— Participants will be divided into two topic groups, Group1 and Group 2, by their interest.  <b>GROUP 1 Breakout Discussion: QMS Audit (Factory Inspection) and QMS Rating</b> —Moderators: Govind Ramu, SunPower and Jenya Meydbray, DNV GL <i>This Group will discuss issues for effective implementation of the IEC TS62941 Guideline for Manufacturing QA, currently under development, including clarification of requirements and audit practices by a test lab/accreditation body. This group will also cover philosophical questions on the need for QMS ratings and desirable QMS rating systems.</i> Feedback from test lab (accreditation body) and module manufacturers <ul style="list-style-type: none"> <li>• Audit of JIS8901 Certification—Yasunori Uchida, JET</li> <li>• DNV GL Product Qualification Program—Jenya Meydbray, DNV GL</li> <li>• TUV-Rheinland QMS Audit Program—Matthias Heinze, TUV Rheinland PTL</li> </ul> Open Discussion <ul style="list-style-type: none"> <li>• Are there questions about the proposal for IEC TS62941 and the need for an international QMS standard?</li> <li>• How should IEC TS62941 be implemented—audit in factory inspection, checklist, training and certification of auditors, certification process, or other method?</li> <li>• Should a comparative QMS rating system differentiate companies and products according to the product quality?</li> </ul> <b>GROUP 2 Breakout Discussion: Climate-Specific Rating</b> —Moderators: Chris Flueckiger and John Wohlgemuth <i>IEC82/766/NP 62892-1 provides a framework for climate-specific rating; however, details of tests, including numbers to specify test conditions, are open for further discussion. Members of this Group are expected to provide suggestions/recommendations for the successful development of effective IEC standards on climate-specific rating tests. (Note: More than one group may be formed on this topic, depending on the number of participants.)</i> <ul style="list-style-type: none"> <li>• Test Protocol and Numbers</li> <li>• How will test results be linked with rating?</li> <li>• Qualification Plus</li> <li>• Discussion of Each Task Group Approach</li> </ul>
<b>3:30–4 p.m.</b>	<b>Coffee Break</b>
<b>4–4:20 p.m.</b>	<b>Breakout Session Wrap-Up</b> <i>Each breakout session team</i>
<b>4:20–5 p.m.</b>	<b>Report of Breakout Session</b> —Tony Sample (Chair) <i>Breakout session chairs</i>
<b>5–5:50 p.m.</b>	<b>Open Discussion</b> —Tony Sample and Masaaki Yamamichi (Chairs)
<b>5:50–6 p.m.</b>	<b>Closing</b> —Sarah Kurtz

### ROOM ASSIGNMENTS

PVQAT Sessions: Ballroom Salons A-D

PVQAT QMS Breakout – Keystone/Telluride

Poster Sessions: Ballroom Salons E-H

PVQAT Climate Specific Breakout – Ballroom Salons A-D

Inverter Group Sessions: Aspen/Snowmass (downstairs)

Note that Copper Creek Restaurant Private Dining Room is available at all times for side meetings as needed.

## POSTER SESSIONS

Poster presenters have been asked to leave their posters up all day Tuesday, Wednesday, and Thursday for adequate viewing. We ask that poster presenters be available next to their posters for discussion during the following times.

### TUESDAY, February 24, 2015

#### POSTER SESSION I

1. Alex Bradley, Tanya Dhir, Yves Poissant Initial analysis of 22-year old PV system in Quebec, Canada
4. Andrew M. Gabor, Rob Janoch, Andrew Anselmo and Halden Field Solar panel design factors to reduce the impact of cracked cells and the tendency for crack propagation
7. Cordula Schmid, Rubina Singh, Philipp Zimmermann, Jacqueline Ashmore Development of Qualification Tests for Glass-Less c-Si Modules
10. David Näsvalld Requirements on accelerated testing to ensure 25 years without moisture ingress problems in the toughest climates
13. Devin A. Gordon, Abdulkerim Gok, Cara Fagerholm, David M. Burns, Timothy J. Peshek, Laura S. Bruckman, Roger H. French Degradation Analysis of Poly(ethylene terephthalate) via Fluorescence Spectroscopy
16. I.E. Anderson, M. Osborne, G. Alers Backsheet reliability of modules for greenhouse application
19. J. Gallon, G. S. Horner, J. E. Hudson, L.A. Vasilyev PV Module Hotspot Detection
22. John Naumovitz, Kumar Nanjundiah, Lisa Madenjian Maximizing Reliability Performance with Polyolefin Encapsulants
25. L.L. Kazmerski, Antonia Sonia A.C. Diniz, Cristiana M. Brasil, Lauro V. Machado Neto, Marcelo Machado, Leila de Oliveira Cruz, G. Tamizhmani Emerging Reliability Issues for Photovoltaic (PV) Modules: Surface Conditions and Fundamental Photon Coupling
28. MaoYi Chang, Haomin Chen, Chienyu Chen, C. H. Hsueh, W. J. Hsieh Water Cooking for Backsheet and PV Module Endurance Evaluation
31. Michael Gostein and Bill Stueve Accurately Measuring PV Power Loss Due to Soiling
34. Nicholas Riedel, Larry Pratt, Erica Moss, and Michael Yamasaki 600 Hour Potential Induced Degradation Testing on Silicon, CIGS and HIT Modules
37. O. Bamiduro, R. Konda Defects during the synthesis of a one-step electrodeposited  $\text{CuIn}_x\text{Ga}_x\text{Se}_2/\text{Mo}$ /glass films at atmospheric conditions
40. Soh Suzuki, Tadanori Tanahashi, Takuya Doi and Atsushi Masuda Sorting test of bending load on the interconnector in crystalline silicon photovoltaic modules
43. Tadanori Tanahashi, Soh Suzuki, Norihiko Sakamoto, Akihiro Mito, Katsuhiko Shirasawa and Hidetaka Takato *In-situ* AC impedance measurement in c-Si PV modules during rapid thermal cycling test
46. Yasunori Uchida Tj measurement of bypass diode for PV modules
49. Sean Fowler Effects of water spray on specimen temperature exposed during proposed xenon arc and fluorescent UV lamp weathering test cycles for backsheet materials
52. John Lippiatt Robustness of SunPower Cells to Wind Stress via High-Cycle Vibration Testing
55. Tatsuo Nakamura Utilization of Ultra-Intense UV Weathering Chambers for Rapid Acceleration of PV Component Testing
58. Tony Sample Long-term soiling in a moderate subtropical climate

61. Eric Schindelholz Characterization of Fire Hazards of Aged Photovoltaic Balance-of-System Connectors

64. Davis Hemenway, Hiroshi Sakurai, Walajabad Sampath, and Kurt Barth Thermal Modeling of PV Modules Using Computational Simulation

### TUESDAY, February 24, 2015

#### POSTER SESSION II

2. Benjamin Figgs, D. Martinez, T. Mirza PV Soiling Rate Variation over Long Periods in Desert Environment
5. Dr. Lars Podlowski, Bernd Litzenburger, Stefan Janke, Daniel Cormode, Stefan Wendland Worst-case partial shading conditions for crystalline silicon solar cells with different reverse-current characteristics
8. Eric Schneller, Joe Walters, Stephen Barkaszi Performance analysis of c-Si module deployed at FSEC after 10 years exposure
11. Russell Geisthardt, John Raguse, Andrew Moore, and James Sites Tracking PV Changes: Bridging Between Thin-Film Cells and Modules
14. Jayesh G. Bokria, Sean A. Ferrigan, Kyle B. Smith, and Luke A. Strzegowski Role of EVA-based encapsulants on Potential Induced Degradation of Crystalline Silicon PV Modules
17. Jeff Thompson, Yoshiaki Takezawa, Clarissa Miller Increased Hydrolytic Stability of Neutral Cure Silicone Adhesives Improves Long-term Module Reliability
20. Justin Luria, Yasemin Kutes, Bryan Huey Accelerated Aging of CdTe Microcells Using Conductive Probe Atomic Force Microscopy
23. M. Propst, N.A. Olsson Pitfalls of Energy Yield Prediction Models Based on Time 0 and STC Module Characterization
26. Masahiro Iwata, Keisuke Ogawa, Hiroshi Kanno, Hiroshi Inoue, Mikio Taguchi and Shingo Okamoto Stability of encapsulants using various string-ribbons
29. Nancy Phillips Backsheet Weathering Study Comparing Light Sources, Irradiance and Temperature Levels
32. Narendra Shiradkar, Vivek Gade Thermal Resistance Measurement of Bypass Diode / Junction Box
35. Lori Postak and Mike Kempe Edge Seal Testing Update
38. Kristopher Toivola, Paul F. Robusto, Bill Kessler Outdoor Performance of CIGS Modules in Different Climates
41. Rie Tanaka and Hirofumi Zenkoh Encapsulant effect on PID durability of various crystalline PV cells
44. Shubhra Bansal, Rebecca Jones-Albertus PV Module and Device Reliability: An Overview of Current Status and Potential Gaps
47. Steve Johnston and Tim Silverman Photoluminescence and Electroluminescence Outdoor Module Imaging
50. V. Bermudez Effect of process fabrication and annealing conditions on stabilization pre-conditioning of CIGS modules
53. Yan Wang, Yong Sheng Khoo, Thomas Reindl PV Module Reliability Studies in the Tropics—and Beyond
56. Zhu, D. Wu, D. Montiel-Chicharro, M. Owen-Bellini, T.R. Betts, and R. Gottschalg Influences of lamination quality on durability of PV modules under damp-heat exposure
59. Haichuan Zhao, Yinbai Li, and Matt Perry Reliability Test and Analysis of Silicone Sealant Used for Sealing and Bonding on PV Modules
62. Kannan Ramanathan and Rebekah Garriss Processing and Device Oriented Approach to CIGS Module Reliability

## POSTER SESSIONS

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### WEDNESDAY, February 25, 2015

#### POSTER SESSION PVQAT

3. Alex Mikonowicz What is the US TAG and what is its function: the official IEC TC 82 description
6. Amy Lefebvre, Greg O'Brien, James D. Knapp, Bryan Douglas, Gunter Moeller, Dana Garcia Effect of QUV A with Thermal Cycling Exposure on PV Backsheets
9. Antonia Sonia A. C. Diniz, Marcelo M. Viana, Cristiana B. Maia, Suellen C.S. Costa, Thiago A. Silverio, Marcio E. M. de Souza, Denio A. Cassini, Francisco H. A. F. Souza, Lawrence L. Kazmerski Field Evaluation of Photovoltaic Modules and Systems
12. Bengt Jaeckel, Marijo Cosic and Jürgen Arp Investigation of c-Si Module Degradation and Recovery Effect under High Potential
15. Brenor Brophy, Sergiu C. Pop, Venkata Abbaraju, Ralf Schulze, Y. Sam Yang, Sina Maghsoudi, Peter Gonsalves Highly Durable Anti-Reflective Anti-Soiling Coating for PV Module Glass
18. David C. Miller, Jayesh G. Bokria, Xiaohong Gu, Christian C. Honeker, Naiara Murua, Nichole E. Nickel, Keiichiro Sakurai, Tsuyoshi Shioda, Govindasamy Tamizhmani, Ethan Wang, Shuying Yang, Toshio Yoshihara, and John H. Wohlgemuth Round-Robin Verification and Final Development of the IEC 62788-1-5 Encapsulation Size Change Test
21. Donald B. Warfield System reliability aspects of currently available modules with atypical string length
24. Doug Vermillion and Tatsuo Nakamura Utilization of Ultra-Intense UV Weathering Chambers for Rapid Acceleration of PV Component Testing
27. Eleonora Annigoni, Federico Galliano, Marko Jankovec, Heng Yu Li, Laure-Emmanuelle PerretAebi, Christophe Ballif, Fanny Sculati-Meillaud Moisture ingress into PV modules: long-term simulations and a new monitoring technique
30. Gerhard Kleiss Quality and Reliability—Sometimes the Customer Wants More
33. Jane Kapur, Kate Stika, Craig Westphal, Sergiu C. Pop, Ralf Schulze, Xiaoguang Wang, Beihai Yuan, Andreas Meisel Prevention of PID with Ionomer film by reducing Sodium-ion Accumulation in Photovoltaic modules
36. J.P.D. Cook, C.T. Li, J. Haysom, K. Hinzer, and H. Schriemer TETRA—Thermal Environment by Transient Response Analysis: Auto-Calorimetry Toward Material and Structure Evolution Studies in Concentrator Photovoltaic Cells
39. Jia Ying Ye, Teck Cheng Tan, REC Solar Rolling Reliability Test and Field Degradation Correlation Investigation in REC Solar
42. Mark Reusser, Matthew Dorogi, Larry McClung Financial Implications of Module Degradation Uncertainty for Utility-Scale Solar Facilities
45. Matevž Bokalič, Kristijan Brecl, Marko Topič Outdoor Stabilization of Thin-Film Photovoltaic Module Performance
48. Nia Thompson The Limiting Effects of Temperature on the Performance of a Crystalline-Si Solar Array in Trinidad and Tobago's Climatic Conditions

51. Ranier Grischke Prolonged Lifetime Performance of Meyer Burger's Hetero Junction Solar Modules
54. Soo-Young Oh An Open Platform to Speed-up and Cost-down the PV Reliability R&D
57. Xiaohong Gu, Chiao-Chi Lin, Peter Krommenhoek, Stephanie Watson Depth Profiling of Chemical and Mechanical Degradation of PV Backsheets after Accelerated Laboratory Exposure under Simultaneous UV, Temperature and Moisture
60. Thomas Weber, Juliane Berghold, Floreian Heilmann, Margarete Roericht, Stefan Krauter, and Paul Grunow Test Sequence Development for Evaluation of Potential Induced Degradation on Thin Film Modules
63. Patrick Trippel Reliability Test and Analysis of Silicone Sealant Used for Sealing and Bonding on PV Modules
65. W. Gambogi, J. Kopchick, T. Felder, S. MacMaster, A. Bradley, B. Hamzavtehrany, C.-F. Wang, H. Hu, Y. Heta, and T. J. Trout Sequential and Weathering Module Testing and Comparison to Fielded Modules

### WEDNESDAY, February 25, 2015

#### POSTER SESSION INVERTER

66. Kenneth Armijo, Jay Johnson, Benjamin Yang, Michael Hibbs and Richard Harrison Arc Fault Photovoltaic Reliability and Plasma Physics of Failure Investigations
67. Faraz Ebneali Sustainability through Product Quality and Compliance
68. Timothy J. Peshek, Mohammad A. Hossain, Roger H. French A Seat at the "Big Table": Temporal Analytics of Inverter Performance

### THURSDAY, February 26, 2015

#### POSTER SESSION IECRE

69. Jonathan O'Neill and Karen Maxwell Reliability Concerns with Module Level Rapid Shutdown
70. Rue Phillips Commissioning, Certification, Acceptance and Performance Testing: What Do They Mean?
71. Richard Lawrence NABCEP PV System Inspector Job Task Analysis

### FRIDAY, February 27, 2015

#### POSTER SESSION PV SOLAR RESOURCE

- Viktar Tatsiankou, John P.D. Cook, Frédéric Carle, Karin Hinzer, Richard Beal The SSIM: Low-Cost Spectral Measurement
- Eiji Takeuchi, EKO Instruments Co., Ltd. Study on Performance Transition of PV System by Monitoring
- Paul Thienpont, Marie Schnitzer, Rebecca Tilbrook, Whitney Wilson How much is plant overproduction costing you? A review of the impacts of solar resource data and energy modeling on project financing
- Taylor Thomas, Dave Johnson, Patrick Morgan, Dave Heinicke, Dayle McDermitt, George Burba, Rex Peterson, John Wurm, and Bill Biggs A New Silicon Photovoltaic Pyranometer for Measuring Solar Irradiance in Meteorological and Solar Resource Applications
- Mark Campanelli Quantifying Uncertainty in PV Performance Delta Measurements

This workshop was made possible by the U.S. Department of Energy Solar Energy Technologies Office. NREL is appreciative of additional organizational support provided by Sandia National Laboratories. We also appreciate participation from the greater solar research community, both in the organization and execution of this workshop.

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NREL/OT-5J00-63811 • February 2015

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