DuraMat Capability 5:
Field Deployment

Poster Number	Capability Name	Short Paragraph Description of Capability (300 words same as the abstract. Summarize what it does and value to DuraMat and Module Materials)	Capability Expert (principal contact)	Organization Name and Type - (National Laboratory - NL, Academic Institution - AI, Company- C)	Which Capability Area Best Fits This Work (Select One)	Define from an industry perspective what near term 1 year and long term 5 year successful use of the capability would be. (100 words)	Link to Your Website (if available)
60	Field Deployment	The DOE Regional Test Centers form a network of five sites spanning the three major climate groups present in the U.S. Jointly managed by Sandia and NREL, sites are located in Albuquerque, NM, Golden, CO, Orlando FL, Burlington, VT and Las Vegas, NV. The RTC's provide test centers across the country where industry - in partnership with the National Labs – can assess regional impacts to the performance, reliability and economic viability of solar photovoltaic (PV) technologies. Currently there are more than 12 industry partners and 300 kilowatts of installed PV in different stages of development. The RTC's also serve as regional test beds in support of Sandia and NREL's projects funded through SuNLaMP. Each site maintains a comprehensive weather station for determining solar resource and other relevant environmental conditions. RTC researchers have developed a standardized data acquisition system tailored to monitoring PV systems that features high accuracy, high sample rates and low thermal drift. The New Mexico RTC is co-located with Sandia's PSEL. PSEL features world-class cell and module characterization facilities, both indoor and outdoor. A unique capability exists in Sandia's two-axis trackers for performance characterization, capable of evaluating individual cells of just a few watts up to interconnected strings of modules as large as 2.4 kW. Indoor module testing capabilities include a Spire 4600 SLP flash tester, custom-built chamber for simultaneous electroluminescence (EL) and Mid-Wave infrared (MWIR) inspection of full size modules, and an Atonometrics light soaking chamber. The indoor cell lab includes a SpectroLab XT-10 solar simulator, Berger Pulsed solar simulator, PV Measurements QEX10 quantum efficiency unit and Cary 5000/DRA2500 spectrophotometer. In addition to characterization equipment, PSEL also possesses basic prototype module fabrication equipment; a small vacuum laminator and a string tabber. Staff at PSEL have many years of experience characterizing prototype PV panels and unconventional form factors.	Bruce King	NL- Sandia National Laboratories	5. Field Deployment	Successful use of the facility in the near term (1 year) will include field deployment of candidate module packaging materials developed through the DuraMat Consortium to complement and validate indoor accelerated testing. Aged material coupons will be provided to materials characterization facilities on predetermined intervals for detailed assessment of degradation. Successful use of the facility in the long term (5 years) will include characterization of module concepts for initial performance and longer term for reliability and degradation. State of the art monitoring systems will be used to assess module performance and degradation in situ.	https://rtc.sandia.gov http://energy.sandia.gov/energy/renewable-energy/solar-energy/photovoltaics/
61	End-of-Life Management of PV Modules: Challenges and Opportunities	An important but heretofore largely overlooked consideration in the development of new PV module designs is their fate at the end of their useful life. Increasing PV deployment eventually leads to increasing end-of-life module waste, analogous to other consumer electronic waste (e-waste). The best available projections suggest that waste PV modules could constitute more than 10% of e-waste globally by 2030 (Figure). Given the historical and anticipated growth in PV module deployment, US regulators will likely soon require and consumers may soon demand affordable, sustainable end-of-life management solutions for waste modules. Currently, there are few recycling solutions offered in the US, partly because there are no market drivers or mandates. A 2012 European Union Directive added PV modules to the list of electronic products requiring the collection and recycling of discarded end-of-life products by the manufacturer selling into the EU market. End of life management entails costs that will be added to those already borne by the manufacturer, thus are important to anticipate and manage, and yet are not currently included in TEA analyses of PV LCOE. The US will need technology and policy solutions soon to address what could become a serious environmental weakness for PV if waste modules start filling landfills or are shipped to developing countries as e-waste. We propose to develop a nationally-unique research and analysis capability in PV recycling and materials recovery for purposes of addressing this growing need. This capability will integrate strategic technoeconomic and sustainability analysis, particularly life-cycle and cost modeling, with materials science and PV device fabrication and manufacturing supply chain expertise. It will incorporate principles of design for recyclability for module and systems. Module and component manufacturers, federal agencies (DOE's SunShot program, Advanced Manufacturing Office, NIST) and regulators (EPA, California Department of Toxic Substances) are all potential clients and collaborators.	Garvin Heath,Mike Woodhouse, Teresa Barnes, Jill Engel-Cox, Rachelle Ihly	NL- NREL	5. Field Deployment	In year 1 we would convene a consortium of PV manufacturers, recyclers and other stakeholders to anonymously pool data regarding recycling process costs and sustainability. Benefits of a consortium approach are that firms could learn from peers and benchmark their systems against others in the field. Analysis of the pooled data would provide insight into cost drivers and identify environmental hot spots, and can inform development of technology R&D roadmaps. Roadmaps should lead to funding opportunities that accelerate and advance innovation. Such roadmaps should be established and initially executed within 5 years. Alongside, considerations of module design for recyclability can be developed, e.g., establishing benchmarks based on specific technical criteria.	
62	Non-Destructive Evaluation of Full-Size PV Panels	The size and construction of modern PV modules present challenges to the identification and characterization of manufacturing defects and field failures. Full size PV modules are too large to fit in most common laboratory inspection instruments. Packaging of PV modules – inherently designed to withstand 25 years or more of field deployment – make extraction of smaller samples difficult or impossible without creating additional damage. Sectioning of PV modules to find failures becomes a "needle in a haystack" exercise if the location of the failure is not known a priori. Techniques such as Electroluminescence and Lock-in Infrared Thermography are commonly used, but these techniques rely on current injection into the module and are best suited to the identification of cell failures. The challenges associated with identifying and characterizing flaws in PV modules are similar to those presented to the aerospace industry. The components to be inspected have high surface area and are thin. Inspection necessarily cannot introduce additional damage. Increasingly, fuselages are made of inhomogeneous composite materials. Here, considerable investment has been made in developing Non-Destructive Testing (NDT) techniques that are rapid, accurate and portable. The NDT group at Sandia specializes in these types of measurements. Relevant capabilities include Computed Tomography, Ultrasonic Diagnostics and Pulsed Thermography. For Duramat, these capabilities will be applied to the investigation of defects/failures within PV modules. Candidate inspection techniques will be evaluated for their effectiveness and where necessary, adapted with new software/analysis techniques. Known failed modules will be compared to known good modules to establish Probability of Detection guidelines. Modules will be sourced from existing DOE funded projects such as Predicts II and partnerships with commercial and utility scale system owners/operators. Once established, characterization techniques will be made available to other Duramat capability areas and industry stakeholders.	Bruce King & David Moore (dgmoore@sandia.gov)	NL- Sandia National Laboratories	5. Field Deployment	Successful use of this capability in the short term (1 year) will include a demonstration of the applicability of aerospace-oriented non destructive inspection techniques to PV modules. Long-term success (5 years) will include adaptation of these methods to the specifics of PV modules and availability of these methods to Duramat and industry stakeholdeers. Long term success will further include dissemination of the methodologies and new analysis or software to enable industry to adopt them directly.	