

1. Session Title

Energy Access and Off-Grid Systems: Technology Innovation for Scalable, Affordable and Sustainable Energy Access Solutions

To provide energy access to anybody and at any part of the world.

2. Abstract

Ensuring universal, affordable, and sustainable energy access is one of the biggest societal challenges of our time. As of 2022, close to a billion people worldwide still live without having access to electricity, and another two billion have unreliable access. The centralized electricity grid is not the optimal choice for remote and rural applications, due to environmental impact, cost, mismatch to user needs and challenges around financial feasibility. Decentralized approaches, such as solar home systems and microgrids, have emerged as a response to shortcomings of the centralized grid approach, but affordability, scalability, interoperability and societal and technical sustainability remain a key challenge. Power electronics technology is one of the key enabling technologies for context-appropriate and sustainable energy access solutions. Some of the key technology areas for innovation are: decentralized bottom-up grids, self-organizing grids and microgrids, DC nanogrids, hyper-efficient appliances, energy storage, autonomous plug-and-play inverters for inverter dominant grids, ultra-automation in AC or DC microgrids etc. This session will reflect on lessons learned from past electrification efforts and showcase some of the exciting technology solutions enabling scalable, affordable and sustainable energy access solutions.

3. Session Organizers

Organizer 1: Dr. Deepak Divan, John E Pippin Chair, GRA Eminent Scholar and Director of the Center for Distributed Energy at the Georgia Institute of Technology in Atlanta, GA.



Dr. Deepak Divan is Professor, John E Pippin Chair, GRA Eminent Scholar and Director of the Center for Distributed Energy at the Georgia Institute of Technology in Atlanta, GA. His field of research is in the areas of power electronics, power systems, smart grids and distributed control of power systems. He works closely with utilities, industry and is actively involved in research, teaching, entrepreneurship and starting new ventures. Dr. Divan also serves as Founder and Chief Scientist at Varentec, in Santa Clara, CA, and was President and CTO from 2011-14, leading the company as it developed its suite of innovative distributed real-time grid control technologies. Varentec is funded by leading green-tech Venture Capital firm Khosla Ventures and renowned investor Bill Gates. Dr. Divan is an elected Member of the US National Academy of Engineering, member of the National Academies Board on Energy and Environmental Systems, a Fellow of the IEEE, past President of the IEEE Power Electronics Society, and is a recipient of the IEEE William E Newell Field Medal. He has 40 years of academic and industrial experience, 65 issued and pending patents, and over 400 refereed publications. He has founded or seeded several new ventures including Soft Switching Technologies, Innovolt, Varentec and Smart Wires, which together have raised >\$160M in venture funding. He received his B. Tech from IIT Kanpur, and his MS and PhD degrees from the University of Calgary, Canada.

Organizer 2: Dr. Philip T. Krein Grainger Endowed Director's Chair in Electric Machinery and Electromechanics as Professor and Director of the Grainger Center for Electric Machinery and Electromechanics.



Dr. Philip T. Krein holds the Grainger Endowed Director's Chair in Electric Machinery and Electromechanics as Professor and Director of the Grainger Center for Electric Machinery and Electromechanics. His research interests address all aspects of power electronics, machines, drives, and electrical energy, with emphasis on nonlinear control and distributed systems. He published an undergraduate textbook, *Elements of Power Electronics* (Oxford University Press, 1998). In 2001, he helped initiate the International Future Energy Challenge, a major student competition involving fuel cell power conversion and energy efficiency. He holds seventeen U.S. patents with additional patents pending. Dr.

Krein is a registered professional engineer in Illinois and in Oregon. He was a senior Fulbright Scholar at the University of Surrey in the United Kingdom in 1997-98, and was recognized as a University Scholar in 1999, the highest research award at the University of Illinois. In 2003, he received the IEEE William E. Newell Award in Power Electronics. He is a past President of the IEEE Power Electronics Society, and served as a member of the IEEE Board of Directors. In 2005-2007, he was a Distinguished Lecturer for the IEEE Power Electronics Society. In 2008, he received the Distinguished Service Award from the IEEE Power Electronics Society. He serves as Academic Advisor for the Department of Electronic and Information Engineering at Hong Kong Polytechnic University. He is Chairman of the Board of SolarBridge Technologies, a developer of long-life integrated solar energy systems.

Organizer 3: Dr. Jelena Popović, Univ. of Twente, The Netherlands



Dr. Jelena Popović received the Dipl. Ing. degree from the University of Belgrade, Serbia, and the Ph.D. degree from the Delft University of Technology, Delft, The Netherlands. From 2005 to 2011, she was with the European Center for Power Electronics (ECPE). From 2008 to 2017 she was with the Delft University of Technology as an Assistant Professor. In 2018 she co-founded a start-up in energy access, Klimop Energy. From October 2019, she joined the Power Electronics group of the University of Twente as a part time Associate Professor. She has published more than 100 publications in scientific journals, magazines and

conferences. She has co-authored strategic research agendas, technology roadmaps and white papers in the field of energy access, power electronics, energy efficiency, solid state lighting. Her recent interests are bottom-up solutions for energy access and socio-technical integration.

Organizer 4: Dr. Issa Batarseh, Professor, University of Central Florida, USA



Dr. Issa Batarseh is a Professor in the Department of Electrical and Computer Engineering at the University of Central Florida (UCF). He received the Ph.D., and M.S. in Electrical Engineering and the B.S. in Computer Engineering and Science from the University of Illinois at Chicago in 1983, '85 and '90, respectively. Dr. Batarseh's power electronics research focuses on the development of advanced systems for solar energy conversion to improve cost, power density, efficiency and performance. The research includes the analysis and design of high frequency dc-ac inverters, resonant converter topologies; low-voltage dc-dc converters, small signal modeling and control of PWM and resonant converters; power factor correction techniques. He is an inventor on 36 patents and author of more than 300 articles and 2 books. Dr. Batarseh has significant commercialization experience as a founder of two start-up companies involved solar energy conversion: Advanced Power Electronics Corp. (APECOR) and Petra Systems. He is also a fellow member in National Academy of Inventors (NAI), AAAS, IEEE, and IEE.

Organizer 5: Dr. Sanjib Kumar Panda, Director, Power & Energy, National University of Singapore



Dr. Sanjib Kumar Panda received B. Eng. Degree from the South Gujarat University, India, in 1983, M.Tech. degree from the Indian Institute of Technology, Banaras Hindu University, Varanasi, India, in 1987, and the Ph.D. degree from the University of Cambridge, U.K., in 1991, all in electrical engineering. Since 1992, he has been holding a faculty position in the Department of Electrical and Computer Engineering, National University of Singapore and is currently serving as an Associate Professor and Director of the Power & Energy Research Area. Dr. Panda has published more than 525 peer-reviewed research papers, co-authored one book and contributed to several book chapters and six patents. His research interests include high-performance control of motor drives and power electronic converters, condition monitoring and condition based maintenance, building energy efficiency, energy access etc. He is also a fellow member in IEEE, and IES, Singapore.

4. Session Speakers

Panelist 1: Sanjib Kumar Panda, National University of Singapore, Singapore –

Title: The Need for Energy Access - Opportunities and Challenges (10 mins.)

Panelist 2: Philip Krein, University of Illinois Urbana-Champaign, USA –

Title: What lessons can be learned from the past and what synergies are with the future - (rural) electrification in the USA, leveraging future developments (15 mins.)

Panelist 3: Deepak Divan, Georgia Institute of Technology, USA

Title: Bottom-up modular grid-forming inverters (15 mins.)

Panelist 4: TBD - DC-based bottom-up solution (15 mins.)

Panelist 5: Issa Batarseh, University of Central Florida, USA

Title: EBL-I/II solution snapshot – showcasing clusters of solutions (15 mins.)

Discussion and Q&A