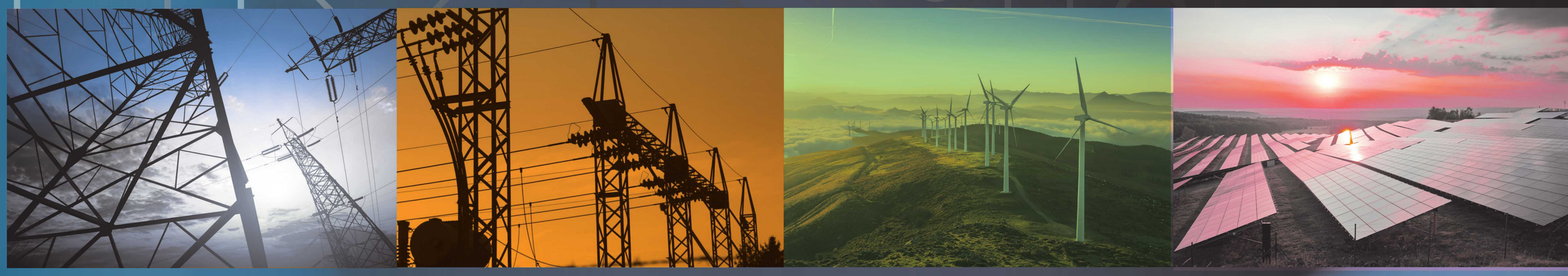
SAND2018-9223C

Welcome to the Grid of the Future Workshop



August 22, 2018

The Centennial Engineering Center at The University of New Mexico

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Sandia National Laboratories

The Grid of the Future Workshop

August 22, 2018

Agenda

8:00 – 8:30 am	Registration, coffee and continental breakfast
8:30 – 8:40 am	**Welcome – Dr. Christos Christodoulou** *Jim and Ellen King Dean of Engineering and Computing, The University of New Mexico*
8:40 – 8:50 am	**Introductory Remarks – Dr. Carol Adkins** *Director, Energy, Earth, and Complex Systems, Sandia National Laboratories*
8:50 – 9:20 am	**Keynote Speaker – Mr. Robert Cummings** *North American Electric Reliability Corporation (NERC), Grid Reliability*
9:20 – 10:35 am	**Grid Interdependencies with Critical Infrastructure** Moderator: Dr. Brian Pierre Dr. Russell Bent; Los Alamos National Laboratory; Gas-Grid Resilient Design Dr. Seth Blumsack; Penn State University; Identifying Vulnerable Critical Infrastructure Dr. Charles Macal; Argonne National Laboratory; Grid-Critical Infrastructure Interdependencies
10:35 – 10:45 am	Break
10:45 – 12:00 pm	**Resilient Distribution Systems** Moderator: Dr. Matthew Reno Dr. Sukumar Brahma; New Mexico State University, Power System Protection in the Era of Smart Grid Dr. Satishkumar Ranade; New Mexico State University; R2- Risk Aware, Resilience Aware Management of Energy Delivery Dr. Chen-Ching Liu; Virginia Tech University; Resilient Distribution Systems
12:00 – 1:00pm	Lunch
1:00 – 2:15 pm	**Evolution of Control Centers and Integrating Renewables** Moderator: Dr. Ali Bidram Dr. Reinaldo Tonkoski; South Dakota State University; Voltage Control Strategies for Distribution Systems with High Penetration of Photovoltaics Dr. Anjan Bose; Washington State University; Evolution of Control Centers for the Future Grid Dr. Babak Enayati; National Grid; DER Interconnection Requirements in Islanded Distribution Systems
2:15 – 2:30 pm	Break
2:30 – 3:45 pm	**EMP Resilience** Moderator: Dr. Jason Neely Dr. Olga Lavrova; Sandia National Laboratories; EMP Grand Challenge Dr. Jane Lehr; The University of New Mexico; EMP Resilience at the Grid of the Future Mr. Charles Bayless; The Climate Institute; The North American Super Grid Project
3:45 – 4:00 pm	Break
4:00 – 5:15 pm	**Grid Stability** Moderator: Dr. David Schoenwald Dr. Daniel Trudnowski; Montana Tech University; Passive versus Active Grid Reliability Dr. John Undrill; Arizona State University; Power and Frequency Control in the Grid of 2050 Mr. Ross Guttromson; Sandia National Laboratories; Mapping Power System Stability Using Machine Learning
5:15 – 5:20 pm	**Closing Remarks – Mr. Charles Hanley** *Senior Manager, Grid Modernization & Resilient Infrastructure, Sandia National Laboratories*
5:20 – 7:30 pm	Reception @ The University of New Mexico Hodgin Hall

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Ray Byrne, *Sandia National Laboratories*

Ali Bidram, *University of New Mexico*

Sukumar Brahma, *Clemson University*

Jane Lehr, *University of New Mexico*

Satish Ranade, *New Mexico State University*

William Tracy, *The Santa Fe Institute*

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Speaker Biographies

Carol Adkins is Director of the Energy, Earth, and Complex Systems Center at Sandia National Laboratories in Albuquerque, New Mexico. Carol provides leadership and management direction for Sandia's applied energy, grid, and geoscience research and development programs. Previously, Carol was Director of the Energy Technologies and System Solutions Center, overseeing all of Sandia's renewable-energy and grid programs. Some of her past management roles include Director of Materials Science and Engineering; Deputy Director of the Nuclear Weapons Science and Technology Strategic Area with responsibility for the National Nuclear Security Administration's science and infrastructure funding at Sandia; and Principal Program Director for the Defense Security Program, including all physical and cyber security at Sandia.

Charles Bayless is a retired Utility Executive and University President. Until June 30, 2008, Mr. Bayless was President and Provost of the West Virginia University Institute of Technology, a divisional Campus of West Virginia University. Prior to Dec 27, 1999 Mr. Bayless specialized in troubled utility restructuring and was Chairman, President, and Chief Executive Officer of Illinova Corporation. Mr. Bayless was Senior Vice President and Chief Financial Officer of Public Service Company of New Hampshire where he guided the company through the first bankruptcy of a large utility. Before that, he was employed by Consumers Power Company in Jackson, Michigan, first as an attorney, then as the Director of Nuclear Fuel Supply, and finally as the Director of Special Corporate Projects. Mr. Bayless received his BSEE from West Virginia Institute of Technology in 1968. In 1971, he earned his MSEE, in power engineering, and in 1972 his law Degree, both from West Virginia University.

Russell Bent received his Ph.D. degree in computer science from Brown University in 2005. Since then he has been a scientist at Los Alamos National Laboratory. He is currently in the Applied Mathematics and Plasma Physics Group (T-5), where he leads LANL's inter-organizational Advanced Network Sciences Initiative (ANSI). Dr. Bent is the principal or co-principal investigator for numerous DOE projects in infrastructures systems with focuses on improving robustness of infrastructure systems to extreme events, increasing resilience of distribution networks, modeling interdependencies between systems, managing disasters that impact critical infrastructure, modeling smart grid technologies, and developing methods for mixed-integer, non-linear optimization. He is the lead developer for the software POD, A Global Solver for Nonconvex MINLPS and the software GasModels.jl, a toolbox for modeling natural gas systems. He is the author of one book, *Online Stochastic Combinatorial Optimization*, and over 80 peer reviewed journal and conference publications. Dr. Bent is also an associate editor for the INFORMS Journal of Computing.

Seth Blumsack is Professor of Energy Policy and Economics and International Affairs in the John and Willie Leone Family Department of Energy and Mineral Engineering at Pennsylvania State University. His research interests include the intersection of engineering, economics, and the regulation of energy and electric power systems. He is currently on the External Faculty of the Santa Fe Institute and is an Adjunct Research Professor with the Carnegie Mellon Electricity Industry Center. He holds a BA degree in mathematics and economics from Reed College, and MS and PhD degree in economics and engineering and public policy, respectively, both from Carnegie-Mellon University.

Anjan Bose received the B.Tech. degree from the Indian Institute of Technology (IIT) Kharagpur, Kharagpur, India, the M.S. degree from the University of California, Berkeley, CA, USA, and the Ph.D. degree from Iowa State University, Ames, IA, USA. He has worked for industry, academe, and government for 40 years in electric power engineering. He is currently a Regents Professor and also an endowed Distinguished Professor of Power Engineering at Washington State University, Pullman, WA, USA, where he also served as the Dean of the College of Engineering and Architecture during 1998–2005. Dr. Bose is a member of the U.S. National Academy of Engineering and a Foreign Fellow of the Indian National Academy of Engineering. He received the Herman Halperin Award and the Millennium Medal from the IEEE and was recognized as a distinguished alumnus by IIT Kharagpur and Iowa State University.

Sukumar M. Brahma received the B.Eng. degree in electrical engineering from Gujarat University, Ahmedabad, India, in 1989, the M.Tech. degree in electrical engineering from the Indian Institute of Technology, Bombay, in 1997, and the Ph.D. degree in electrical engineering from Clemson University, Clemson, SC, in 2003. From 1990 to 1999, he was a Lecturer in the Electrical Engineering Department at Birla Vishvakarma Mahavidyalaya Engineering College, Vallabh Vidyanagar, India. From 2003 to 2007, he was Assistant Professor at Widener University, Chester, PA. From 2008 to 2018 he was a faculty at New Mexico State University, Las Cruces, where he became the William Kersting Endowed Chair Professor. He is currently the South Carolina Electric & Gas Distinguished Professor at Clemson University. Dr. Brahma is the past Chair of IEEE Power and Energy Society's Life Long Learning Subcommittee, past Chair of Distribution System Analysis Subcommittee, past Chair of Power and Energy Education Committee, and a member of the Power System Relaying Committee (PSRC). He is an editor for IEEE Transactions on Power Delivery, and served as Guest Editor-in-Chief for the Special Issue on Frontiers of Power System Protection for the journal.

Christos Christodoulou served as the chair of the Electrical and Computer Engineering Department from 1999 to 2005. He is a Fellow member of IEEE, a member of Commission B of URSI, an IEEE AP-S Distinguished Lecturer (2007-2010), and a Distinguished Professor at UNM. Currently, he is the Dean for the School of Engineering and Computing. He has advised over 30 Ph.D. students and over 70 M.S, has published over 500 papers in journals and conferences, has 17 book chapters and has co-authored 8 books. He is one of the founders of UNM's COSMIAC (formerly the Configurable Space Microsystems Innovations & Applications Center), serving as its director from 2012 to 2014. Christodoulou is an IEEE Fellow and has received a variety of awards and honors over the years for his work, including the 2010 IEEE John Krauss Antenna Award for his work on reconfigurable fractal antennas, the IEEE Outstanding Engineering Educator in 2012 (Albuquerque section), and was inducted in the Alumni Hall of Fame for the Department of Electrical and Computer Engineering at North Carolina State University in 2016. He was appointed an IEEE AP-S Distinguished Lecturer from 2007 to 2010.

Robert W. Cummings – NERC Senior Director of Engineering and Reliability Initiatives. Mr. Cummings joined NERC in 1996 and has extensive experience in the industry in system planning, operations engineering, and wide area planning. He holds a Bachelor of Science Degree in Power System Engineering from Worcester Polytechnic Institute and is an IEEE Senior Member. He is a member of the U.S. Department of Energy (DOE) Energy Advisory Committee, and its Energy Storage and Smart Grid Subcommittees. Cummings is also a member of the Scientific Advisory Board of CURENT (Center for Ultra-wide Area Resilient Electric Energy Transmission Networks), a National Science Foundation and Department of Energy Engineering Research Center. His geographically diverse experience includes Central Vermont Public Service Corporation in System Planning (generation and transmission), Public Service Company of New Mexico (Operations Engineering and Wide Area Planning), and the East Central Area Reliability Coordination Agreement (ECAR), a former regional office of NERC.

Babak Enayati received his PhD in Electrical Engineering from Clarkson University, Potsdam, NY in 2009. He is currently a Lead Research Development and Demonstration Engineer at National Grid, Waltham, MA. He joined IEEE in 2006 and currently is Senior Member, IEEE and the IEEE PES Governing Board Member-At-Large. Babak is the Vice Chair of the IEEE Standards Coordinating Committee 21 (SCC21) and IEEE 1547, Standard for Interconnecting Distributed Resources with Electric Power Systems. Babak is also the Chair of IEEE PES Distributed Resources Integration working group. Babak is a registered Professional Engineer (PE) in the state of Massachusetts.

Charlie Hanley is Senior Manager of the Grid Modernization and Resilient Infrastructures Group at Sandia National Laboratories. His group conducts research on enhancing the resilience of our critical energy infrastructures, including grid-scale optimization, controls, and microgrids; energy storage technologies; renewable energy integration; power electronics; cyber security; and advanced analytics for complex systems. He joined Sandia in 1988 and has been working in Sandia's renewable energy and electric grid programs since 1994. From 2005 through 2014, Charlie managed Sandia's Photovoltaics and Distributed Systems Integration Program. Prior to that, he managed Sandia's international renewable energy programs, through which he oversaw the implementation of more than 400 photovoltaic and wind energy systems in Latin America. He received his B.S. in Engineering Science from Trinity University in San Antonio, Texas, and his M.S. in Electrical Engineering from Rensselaer Polytechnic Institute, in Troy, New York.

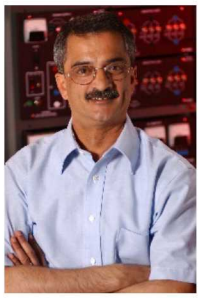
Ross Guttromson received his B.S.E.E. and M.S.E.E. degrees from Washington State University, and his Executive MBA degree from the University of Washington. Ross is Principal Researcher in the area of Electric Power Systems at Sandia National Laboratories with focus on transmission operations and planning. Ross has held research and management positions at both Sandia National Labs and at the Pacific Northwest National Laboratory. He was also with R.W. Beck and Westinghouse Power Corporation. Mr. Guttromson served on the nuclear submarine USS Tautog (SSN 639), is a licensed Professional Engineer and a Senior Member of the IEEE.

Olga Lavrova is currently a Principal Member of the Technical Staff in the Renewable and Distributed Systems Integration Department at Sandia National Laboratories. Prior to this, Dr. Lavrova was an Assistant Professor in the Electrical and Computer Engineering Department at the University of New Mexico. Dr. Lavrova's research interests include photovoltaics and other emerging renewable energy technologies, as well as nano-scale semiconductor structures and their applications. Being a member of the Power and Energy group at the ECE Department, Dr. Lavrova's research interests include photovoltaics and nano-scale semiconductor structures for photovoltaic applications, as well as Smart Grid and emerging energy generation, distribution and storage technologies. Dr. Lavrova holds a Ph.D. in electrical engineering from the University of California at Santa Barbara, an M.Sc. in electrical engineering A.F. Ioffe Physics Technical Institute, Russia and University College London, and a B.Sc. (Summa Cum Laude) in Physics from the St. Petersburg Electrical Technical University.

Jane Lehr is a professor at the University of New Mexico since 2013 and a Fellow of the IEEE since 2008. Dr. Lehr served as chair of the Electrical and Computer Engineering Department from 2013 to 2015. She is an active researcher in the Applied Electromagnetics Group where the thrust of her research has been studying pulsed power generation and applications and high voltage phenomena. Dr. Lehr served as President of the IEEE Nuclear and Plasma Sciences Society in 2007-2008 and currently serves as the society's Fellow Evaluation Chair. Professor Lehr is the recipient of the 2015 IEEE Nuclear and Plasma Sciences Society's Richard F. Shea Distinguished Member Award.

Chen-Ching Liu is American Electric Power Professor and Director, Power and Energy Center, at Virginia Tech. He was Boeing Distinguished Professor at Washington State University, Pullman, WA. During 1983-2005, he was a Professor of Electrical Engineering at University of Washington, Seattle. Dr. Liu was Palmer Chair Professor at Iowa State University from 2006 to 2008. From 2008-2011, he served as Acting/Deputy Principal of the College of Engineering, Mathematical and Physical Sciences at University College Dublin, Ireland. Professor Liu received an IEEE Third Millennium Medal in 2000 and the Power and Energy Society Outstanding Power Engineering Educator Award in 2004. In 2013, Dr. Liu received a *Doctor Honoris Causa* from Polytechnic University of Bucharest, Romania. Chen-Ching chaired the IEEE Power and Energy Society Fellow Committee, Technical Committee on Power System Analysis, Computing and Economics, and Outstanding Power Engineering Educator Award Committee. He served on the U.S. National Academies Board on Global Science and Technology. Professor Liu is a Fellow of the IEEE and Member of the Washington State Academy of Sciences.

Charles Macal applies computational modeling and simulation tools to complex systems to solve problems in a variety of fields, including energy and national security. He is the chief scientist for the Argonne Resilient Infrastructure Initiative, and is a principal investigator for the development of the widely used Repast agent-based modeling toolkit. He has Appointments at the University of Chicago Computation Institute and the Northwestern-Argonne Institute for Science and Engineering. He is adjunct professor at the University of Chicago, where he teaches a course on Complex Adaptive Systems for Threat Management and Emergency Preparedness. He is a registered professional engineer in the State of Illinois and holds software copyrights for two systems: ELIST (Enhanced Logistics Intra-theater Support Tool) and EMCAS (Electricity Market Complex Adaptive System). He holds a B.S. and M.S. from Purdue University, and a Ph.D. from Northwestern University. He is a member of the Association for Computing Machinery and serves as the Area Editor for Agent-based Modeling for the Transactions on Modeling and Computer Simulation. He is also a member of the Society for Computer Simulation International, and serves as Associate Editor for the Simulation Journal.



Satish Ranade is the PNM Chair Professor in Utility Management and department head of the Klipsch school of Electrical and Computer Engineering, New Mexico State University. He teaches in the Power and Control group and is the Director of the Electric Utility Management Program(EUMP), an entirely industry-funded program that provides MSEE fellowships in the energy area. EUMP graduates hold leadership positions in electric utilities and related industry. His current research is in Renewable Energy Integration and Microgrids. As co-director of the NSF Smartgrid CREST center at NMSU, iCredits, he is involved in research on scheduling and control in renewable rich power systems and in K-12 outreach and interdisciplinary curriculum development. He is past chair of IEEE Power and Energy Society's Career Promotion and Workforce Development Subcommittee.

Reinaldo Tonkoski received his B.A.Sc. degree in Control and Automation Engineering, in 2004, he M.Sc. in Electrical Engineering in 2006 from PUC-RS (Pontifícia Universidade Católica do RS), Brazil, and his Ph.D. in 2011 from Concordia University, Canada. He was with CanmetENERGY, Natural Resources Canada, from January 2009 to January 2010 where he worked on projects related to the grid integration of renewable energy sources. Presently, he is an Associate Professor in the Electrical Engineering and Computer Science Department, South Dakota State University, Brookings, US. Dr. Tonkoski has authored over eighty peer reviewed publications and is a Senior Member of the IEEE. His research interests include grid integration of renewable energy systems, distributed generation, power quality and power electronics.

Daniel J. Trudnowski received the B.S. degree in engineering science from Montana Tech, Butte, in 1986, and the M.S. and Ph.D. degrees in electrical engineering from Montana State University in 1988 and 1991, respectively. From 1991–1995, he was with Battelle, Pacific Northwest National Laboratory where he was a senior research engineer. In 1995, he joined Montana Tech where he is currently Dean of the School of Mines and Engineering. Prior to this, he was professor and head of the Electrical Engineering Department. His research activities over the past 20 years have primarily focused on problems related to power system dynamics and controls. Dr. Trudnowski is a member of the IEEE Power System and Control System Societies and is a registered professional engineer in the state of Montana. Dr. Trudnowski is a Fellow of the IEEE.

John Undrill holds a B.E. (Hons) and Ph.D. from the University of Canterbury, New Zealand. He is a registered Professional Engineer in the state of New York, a Fellow of the IEEE, and a member of the National Academy of Engineering. John Undrill commenced his professional training in the Electrical Test Room of New Zealand Electricity Department. Dr. Undrill was a Postdoctoral Fellow at the University of Toronto in 1966 and then joined the Electric Utility Engineering Operation of General Electric in Schenectady. He worked at GE until 1970; this period was his professional internship in power system and power plant dynamics. Undrill joined Power Technologies Incorporated in 1972. At PTI he divided his time between engineering and software. He managed the development, marketing and support of the PSS/E grid simulation for most of his 16 years with PTI. He became a Vice President and Director of PTI before departing to join in founding Electric Power Consultants Incorporated in 1986. His professional work at PTI in addition to PSS/E covered a broad range of general dynamics issues including:

- Hydro plant pipeline, tunnel, draft tube, and turbine-governor interactions
- Oil-fired boiler draft controls
- Automatic generation control programs for digital SCADA systems
- Subsynchronous resonance
- Interaction between DC and AC transmission systems

John's work at EPC was the same combination of software and engineering related to power system dynamics. This led to the development of the PSLF grid simulation package. EPC was acquired by General Electric in 1994 and John returned to his former home at GE. At GE he now handed the support of the PSLF program over to others. His principal activity was then in advising and counseling the GE turbine departments on matters relating to the Grid Codes of the many nations where large gas turbines are being commissioned. This involved the development of new analysis, startup work, field testing, and extensive policy-level contact with grid entities in Europe and worldwide. John received the Edison Award of General Electric in 2005 and the Concordia Award of the IEEE in 2006. He was elected to membership of the National Academy of Engineering in 2011. Undrill's experience embraces small isolated power systems like those of New Zealand and Ireland, the major grids of North America and Europe, and systems as varied as those in Brazil, Argentina, Egypt, Turkey, Singapore, and Malaysia. His startup and test experience covers hydro, conventional steam, and combined cycle plants. Dr Undrill was a member of the commission appointed by Bonneville Power Administration to investigate the 1996 breakup of the Western Transmission grid. His transmission grid experience is complemented by work with in-plant generation in the refinery, paper, LNG, and steel industries. John Undrill retired from General Electric in April 2006; he continues to be active in power system and power plant control engineering.

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