

The Future of Electric Power in the U.S.

Committee

M. Granger Morgan

Chair

Granger Morgan (NAS) is the Hamerschlag University Professor of Engineering at Carnegie Mellon University. He holds appointments in three academic units: the Department of Engineering and Public Policy; the Department of Electrical and Computer Engineering; and the H. John Heinz III College. His research addresses problems in science, technology, and public policy with a particular focus on energy, environmental systems, climate change, and risk analysis. Much of his work has involved the development and demonstration of methods to characterize and treat uncertainty in quantitative policy analysis. At Carnegie Mellon he is co-director of the Center for Climate and Energy Decision Making and the Carnegie Mellon Electricity Industry Center. He has served on a number of advisory committees related to energy issues in the U.S. and Europe. At the National Academies he is the NAS co-chair of the Report Review Committee and has been involved in a variety of other NAS/NRC activities and studies. He is a member of the American Academy of Arts and Science, and a fellow of the IEEE, the SRA and the AAAS. He holds a B.A. from Harvard College (1963) and a Ph.D. from the Department of Applied Physics and Information Sciences at the University of California at San Diego (1969).

Anuradha M. Annaswamy

Member

Anuradha Annaswamy is the Director of the Active-Adaptive Control Laboratory at MIT and a Senior Research Scientist in the Department of Mechanical Engineering. Her research interests pertain to adaptive control theory and applications to aerospace, automotive, and propulsion systems, cyber physical systems science, and CPS applications to Smart Grids, Smart Cities, and Smart Infrastructures. Dr. Annaswamy received her PhD in Electrical Engineering from Yale in 1985. Her research is supported by NSF RIPS, NSF Eager awards, NSF CPS Synergy, NSF CPS Breakthrough, Boeing, Ford-MIT Alliance, Department of Energy, and Air-Force Research Laboratory. Dr. Annaswamy is the author of a hundred journal publications and numerous conference publications, co-author of a graduate textbook on adaptive control (2004), and co-editor of several reports including 'Systems & Control for the future of humanity, research agenda: Current and future roles, impact and grand challenges,' (Elsevier) 'IEEE Vision for Smart Grid Control: 2030 and Beyond,' (IEEE Xplore) and Impact of Control Technology, (ieeecss.org/main/loCT-report, ieeecss.org/general/loCT2-report). She has received several awards including the George Axelby and Control Systems Magazine best paper awards from the IEEE Control Systems Society (CSS), the Presidential Young Investigator award from NSF, the Hans Fisher Senior Fellowship from the Institute for Advanced Study at the Technische Universität München, the Donald Groen Julius Prize from the Institute of Mechanical Engineers, a Distinguished Member Award, and a Distinguished Lecturer Award from IEEE CSS. Dr. Annaswamy is a fellow of the IEEE and IFAC. She is the President Elect of the IEEE CSS for 2019, and will be the President of IEEE CSS in 2020. She is the Deputy Editor of the Elsevier publication Annual Reviews in Control (2016-present).

Anjan Bose

Member

Anjan Bose (NAE) is Regents Professor and Distinguished Professor of Electric Power Engineering at Washington State University. He has over 35 years of experience in industry and academia, as an engineer, educator, and administrator. He holds the endowed Distinguished Professorship in Power Engineering and is the Site Director of the NSF sponsored Power System Engineering Research Center. From 1998-2005 he served as the Dean of the College of Engineering and Architecture. From 1993-1998, he was the Director of the School of Electrical Engineering and Computer Science. A Fellow of the IEEE, he was the recipient of the Outstanding Power Engineering Educator Award (1994), the Third Millennium Medal (2000), and the IEEE's Herman Halperin Electric Transmission & Distribution Award (2006). He has been recognized as a distinguished alumnus of the Indian Institute of Technology, Kharagpur (2005) and the College of Engineering at Iowa State University (1993). During 2011-2013, Prof. Bose served as Senior Advisor to the US Department of Energy, where he coordinated all DOE activities on grid modernization.

Terry Boston

Member

Terry Boston (NAE) served as CEO of PJM Interconnection, the largest power grid in North America and the largest electricity market in the world. Mr. Boston is a 2017 U.S. Presidential appointee to the National Infrastructure Advisory Council (NIAC/DHS). Mr. Boston is past president of the Association of Edison Illuminating Companies and past president of GO 15, the association of the world's largest power grid operators. He also served as a U.S. vice president of the International Council of Large Electric Systems and is a past chair of the North American Transmission Forum. He also was one of the eight industry experts selected to direct the North American Electric Reliability Corporation (NERC) investigation of the August 2003 Northeast/Midwest blackout. In 2011, Mr. Boston was honored with the "Leadership in Power" award from the IEEE Power and Energy Society. He also was chosen by Intelligent Utilities Magazine as one of the Top 11 Industry Movers and Shakers, and led PJM to win Platts Global Energy Awards in Industry Leadership 2010 and Excellence in Electricity in 2012 and in December 2015 he was unanimously selected the winner of the Global Energy Life Time Achievement Award. He received a B.S. in Engineering from the Tennessee Technological University and an M.S. in Engineering Administration from the University of Tennessee. He has served on NAE study committees on 'Analytical Research Foundations for Next-Generation Electric-Grid', 'Evaluation of ARPA-e Mission and Goals' and 'Enhancing the Resilience of the Nation's Electric Power and Distribution (T&D) System'.

Jeffery Dagle

Member

Jeffery Dagle is chief electrical engineer for electricity infrastructure resilience at the Pacific Northwest National Laboratory (PNNL). He currently manages several projects in the areas of transmission reliability, system operations, and security, including the Grid Modernization Laboratory Consortium (GMLC) and the North American SynchroPhasor Initiative (NASPI). In 2018 Mr. Dagle was appointed interim co-director of the Advanced Grid Insittute, a joint institute with PNNL and Washington State University. In addition, he led the cyber security reviews for the DOE Smart Grid Investment Grants and Smart Grid Demonstration Projects; was a member of a National Infrastructure Advisory Council (NIAC) study group formed in 2010 to establish critical infrastructure resilience goals; supported the DOE Infrastructure Security and Energy Restoration Division with on-site assessments in New Orleans following Hurricane Katrina in 2005, and led the data requests and management task for the U.S.-Canada Power System Outage Task Force investigation of the August 14, 2003, blackout. Mr. Dagle is the recipient of several patents. He received the 2001 Tri-City Engineer of the Year award by the Washington Society of Professional Engineers, a Federal Laboratory Consortium (FLC) Award in 2007, and two R&D 100 Awards: in 2008 for the Grid Friendly™ Appliance Controller technology, and 2018 for the Dynamic Contingency Analysis Tool (DCAT). He is a Senior Member of the IEEE and a member of the National Society of Professional Engineers (NSPE). He received B.S. and M.S. degrees in electrical engineering from Washington State University in 1989 and 1994, respectively. He previously served on two NRC study committees: the Committee on Analytical Research Foundations for the Next-Generation Electric Grid, and the Committee on Enhancing the Resilience of the Nation's Electric Transmission and Distribution (T&D) System.

Deepakraj M. Divan

Member

Deepakraj Divan (NAE) is Professor and Director of the Center for Distributed Energy at the Georgia Institute of Technology in Atlanta, GA. Dr. Divan is also John E Pippin Chair and GRA Eminent Scholar. 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 U.S. National Academy of Engineering, 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 more than \$150M in venture funding. He received his B. Tech from IIT Kanpur, and his M.S. and Ph.D. degrees from the University of Calgary, Canada. He has been a Professor at the University of Wisconsin-Madison from 1985 to 1995, and has been with Georgia Tech since 2004. He has taken time off from academia to found and run two companies – Soft Switching Technologies from 1995-2004, and Varentec from 2011-2015.

Michael Howard

Member

Michael Howard is the President and CEO at the Electric Power Research Institute (EPRI). Howard has over 30 years of results-driven, multi-faceted leadership experience in organizations ranging from entrepreneurial start-ups to large public companies with increasing responsibilities in operations, finance, sales and marketing, product development, and strategic planning. Most of his experience is in providing technical consulting services and products to both U.S. and international electric utility companies. Prior to his current appointment, Dr. Howard served as Senior Vice President, Research and Development, and President and Chief Executive Officer of EPRI Solutions, Inc., a wholly-owned subsidiary of EPRI. EPRI Solutions was created by the merger of three companies, one of which was the EPRI Power Electronics Application Center (PEAC) Corporation where he served as President and Chief Executive Officer. Previously, Dr. Howard was President of the Tennessee Center for Research and Development (TCRD) located in Knoxville, Tennessee and President of Beta Development Corporation (BDC), an early-stage venture capital firm focused on providing equity investment in technology-based companies. Dr. Howard began his career in 1980 with Westinghouse Electric Corporation as an applications engineer for the fossil and nuclear digital control systems group. Howard holds a Bachelor of Science in electrical engineering from the University of Tennessee, a Master of Science in business and engineering management from the University of Pittsburgh, and a doctorate in engineering science from the University of Tennessee. He has also completed the MIT Reactor Technology Course.

Cynthia Hsu

Member

Cynthia Hsu is the Cyber Security Program Manager for the National Rural Electric Cooperative Association (NRECA). Dr. Hsu is responsible for establishing and maintaining relationships with more than 900 member electric cooperatives, and developing and implementing cyber security research programs that address issues relevant to NRECA's members. She currently manages a \$20 million cyber security research budget that includes competitive federal grants and contracts, and member-funded research. Prior to her position at NRECA, Dr. Hsu worked for the U.S. House of Representatives' Committee on Science, Space, and Technology, where she staffed Congressional hearings and drafted legislation authorizing a comprehensive research and development program for industrial control systems cyber security covering four federal agencies (Department of Energy, Department of Homeland Security, National Institute of Standards and Technology, and the National Science Foundation). Dr. Hsu was an American Association for the Advancement of Science (AAAS) Science and Technology Policy Fellow for the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability before her position on the House Committee. Dr. Hsu has more than 15 years of experience designing and implementing technical research projects based on stakeholder input to address stakeholder needs. She received her M.S. from Cornell University, and her Ph.D. from the University of Minnesota. Both degrees were in the biological sciences with an emphasis on spatial statistics and spatial analysis.

Reiko A. Kerr

Member

Reiko A. Kerr is the Senior Assistant General Manager of Power System at the Los Angeles Department of Water and Power (LADWP). Since joining in November 2016, she had held primary responsibility over engineering, planning, technical studies, wholesale energy procurement, external generation, strategic planning and initiatives, new business development, and technology applications. Ms. Kerr is also responsible for developing strategies to transition to a 100% clean energy future, while modernizing LADWP's generation, transmission, and distribution facilities to ensure the long-term reliability of the power system. Prior to joining the LADWP, Ms. Kerr served in a number of positions at Riverside Public Utilities, including as the Assistant General Manager of Power Resources, Assistant General Manager of Finance/CFO, Finance & Rates Manager, and Energy Risk Manager. Ms. Kerr has spent over 18 years working in the public utility industry, all in managerial positions. Prior to working in the utility industry, Ms. Kerr spent seven years working in the public accounting and finance field. Ms. Kerr is a founding member and current board member of the Association of Women in Water, Energy and Environment. Ms. Kerr is/has served on Board or Committees of the: American Public Power Association, California Municipal Utilities Association, Southern California Public Power Authority, Large Public Power Council, Western Electricity Coordinating Council. She has served on the following Transmission and/or Generation Project Committees: Intermountain Power Project, San Onofre Nuclear Generating Station, Mead-Adelanto Project, Mead-Phoenix Project, Boulder Canyon (Hoover Project), and Western Energy Institute. Ms. Kerr holds a bachelor's degree in business administration from California State University at San Bernardino and is a certified public accountant in the State of California.

Karen L. Palmer

Member

Karen Palmer is a Senior Fellow and Director of the Future of Power Initiative at Resources for the Future. Dr. Palmer has been a researcher at Resources for the Future for over 25 years. Dr. Palmer specializes in the economics of environmental regulation and public utility regulation, particularly on issues at the intersection of climate policy and the electricity sector. Her work seeks to improve the design of incentive-based environmental and technology regulations that influence the electric utility sector and to help inform its ongoing transition. To these ends, she explores new designs for policies targeting carbon emissions, analyzes efficient ways to promote use of renewable sources of electricity and energy efficiency and investigates market and regulatory reforms to pave the way for long-term de-carbonization of electricity supply and electrification of the energy economy. She is co-author of the book, *Alternating Currents: Electricity Markets and Public Policy*, published by RFF Press. In the 1990s, Dr. Palmer spent six months as a visiting economist in the Office of Economic Policy at the Federal Energy Regulatory Commission where she worked on wholesale market design in the nascent ISO markets. She has served on two National Research Council study panels, one on new source review for stationary sources and a second on the future of electricity from renewables. She serves on the Environmental Advisory Council to the New York ISO, the Advisory Council to the Center for Climate and Energy Decision Making at Carnegie Mellon University, and the Research Advisory Board to the American Council for an Energy Efficient Economy. She is the recipient of the Public Utility Research Center's 2015 Distinguished Service Award and was elected as a fellow of the Association of Environmental and Resource Economists in 2018. Her published papers have appeared in a number of academic journals including the *American Economic Review*, the *RAND Journal of Economics*, *The Journal of Political Economy*, *The Energy Journal*, and *The Journal of Environmental Economics and Management*.

H. Vincent Poor

Member

H. Vincent Poor (NAE/NAS) is the Michael Henry Strater University Professor of Electrical Engineering at Princeton University. He is a specialist in wireless telecommunications, smart grids, signal processing and information theory. His current research activities focus on advances in several fields of rapid technology development, notably wireless networks, energy systems and social networks. Dr. Poor's work in energy systems is focused on smart grids and on the use of advanced methods from communications and information technology to address several issues arising in this context, including the detection and amelioration of bad data and physical attacks on the grid, the study of privacy issues for both operators and consumers, the development of distributed algorithms for state estimation and control of the grid, and the use of game theory and prospect theory to develop an understanding of the behavior of grid participants. From 2006 – 2016, Dr. Poor served as Dean of Engineering and Applied Science at Princeton University. He has also held visiting positions at Imperial College London, Stanford University, UC Berkeley, Harvard University and Cambridge University. He received his M.S. from Auburn University and his M.A. from Princeton University. Both degrees are in electrical engineering. Dr. Poor holds a Ph.D. from Princeton University in Electrical Engineering and Computer Science.

William H. Sanders

Member

William H. Sanders is a Herman M. Dieckamp Endowed Chair in Engineering and Interim Director of the Discovery Partners Institute at the University of Illinois. Dr. Sanders's research interests include secure and dependable computing and security and dependability metrics and evaluation, with a focus on critical infrastructures. He has published more than 270 technical papers in those areas. He served as the Director and PI of the DOE/DHS Trustworthy Cyber Infrastructure for the Power Grid (TCIPG) Center, which is at the forefront of national efforts to make the U.S. power grid smart and resilient. He was the 2016 recipient of the IEEE Technical Field Award, Innovation in Societal Infrastructure, for “assessment-driven design of trustworthy cyber infrastructures for societal-scale systems”. He is also co-developer of three tools for assessing computer-based systems: METASAN, UltraSAN, and Möbius. Möbius and UltraSAN have been distributed widely to industry and academia; more than 1,900 licenses for the tools have been issued to universities, companies, and NASA for evaluating the performance, dependability, and security of a variety of systems. He is also a co-developer of a tool for assessing the networked systems that is available commercially under the name NP-View from the company Network Perception, which he co-founded.

Susan F. Tierney

Member

Susan Tierney, a Senior Advisor at Analysis Group, is an expert on energy economics, regulation, and policy, particularly in the electric and gas industries. She has consulted to businesses, government agencies, foundations, tribes, environmental groups, and other organizations on energy markets, economic and environmental regulation and strategy, and climate-related energy policies. She has participated as an expert in civil litigation cases, regulatory proceedings before state and federal agencies, and business consulting engagements. Previously, she served as the Assistant Secretary for Policy at the U.S. Department of Energy, and was the Secretary for Environmental Affairs in Massachusetts, Commissioner at the Massachusetts Department of Public Utilities, and Executive Director of the Massachusetts Energy Facilities Siting Council. She co-authored the energy chapter of the National Climate Assessment, and serves on the boards of ClimateWorks Foundation, Barr Foundation, Energy Foundation, Resources for the Future, and World Resources Institute. She taught at the Department of Urban Studies and Planning at MIT and at the University of California at Irvine, and has lectured at Harvard University, University of Chicago, Yale University, New York University, Tufts University, Northwestern University, and University of Michigan. She earned her Ph.D. and Masters in regional planning at Cornell University and her B.A. at Scripps College.

David G. Victor

Member

David Victor is Director of the Laboratory on International Law and Regulation and a professor at the School of Global Policy and Strategy at UC San Diego. He also co-leads the UC San Diego Deep Decarbonization Initiative, a campus-wide research and teaching program. His research focuses on how regulatory law affects the environment and the operation of major energy markets. Prior to joining UC San Diego, Victor served as director of the Program on Energy and Sustainable Development at Stanford University where he was also a professor at the law school. He also served on EPRI's Advisory Council, which is comprised of regulators, environmentalists, utility executives and academicians, who help inform the development of the institute's research portfolio. Victor is currently a member of EPRI's Board of Directors. He chairs the community engagement panel that is helping to steward the safe and responsible closure of the San Onofre Nuclear Generation Station (SONGS) and is on the advisory council for the Intitute of Nuclear Power Operations (INPO). He has contributed to numerous publications on topics such as energy market innovations and electric power market reform.

Elizabeth J. Wilson

Member

Elizabeth Wilson is a Professor of Environmental Studies and the inaugural Director of the Arthur L. Irving Institute for Energy and Society at Dartmouth College. She studies how energy systems are changing in the face of new technologies and new societal pressures. Her work focuses on the implementation of energy and environmental policies and laws in practice. She studies how institutions support and thwart energy system transitions and focuses on the interplays between technology innovation, policy creation, and institutional decision making. Recent research has examined how energy policy stakeholders view the opportunities and challenges of creating smart grids and decision making within Regional Transmission Organizations, which manage the transmission planning, electricity markets and grid operations of over 70 percent of North America. Her research has also examined how stakeholders in different U.S. states view emerging energy technologies like wind power and carbon-capture and sequestration and the electric power transmission system. Her recent books include *Energy Law and Policy* (West Academic Publishing) (with Davies, Klass, Tomain and Osofsky) and *Smart Grid (R)evolution: Electric Power Struggles* (Cambridge Press) (with Stephens and Peterson). Wilson's research group is working on two NSF supported grants on media and stakeholder perceptions of Smart Grid technologies and on decision making in Regional Transmission Organizations.