IEEE ENERGY CONVERSION CONGRESS & EXPO Nashville, TN | OCT.29-Nov.2

Tutorial Title

Power Electronics Intensive Power Systems: Dynamic Modeling and Control, Hardware Testing, and Standardization

Instructor Team

A multi-disciplinary and highly diversified instructor team, covering both academia and industry interests and with well gender balance, has been assembled focusing on the topic of power electronics intensive power systems. The instructors are listed below:

Dr. Xiaonan Lu, Associate Professor (academia) Purdue University, West

Dr. Wei Du, Senior Research Engineer (government laboratory) Pacific Northwest National

Dr. Mariko Shirazi, President's Professor in Energy (academia) University of Alaska

Dr. Jing Wang, Senior Research Engineer (government laboratory) National Renewable Energy

Dr. Christopher Rowe, R&D and Microgrid Control Specialist (industry) Enphase Energy

Abstract

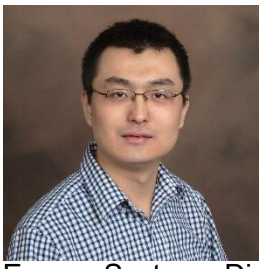
There are tremendous research efforts and industry practices for enhancing grid resilience and stability with increasing penetration of inverter-based resources, with special emphasis on grid-forming and grid-following inverters, localized and network-interconnected microgrids, and advanced substation modeling and control, among others. The challenges are identified in multiple sections throughout the electric power systems, ranging from grid-edge end users to large-scale distribution systems and bulk power grids. It is noteworthy that resilient and stable power electronics intensive power systems are urgently needed to modernize electric power grids with a high penetration level of inverter-based resources (IBRs) for guaranteed operational continuity. Conventional grid-interactive power electronic inverters mainly focus on satisfying the design constraints on control and hardware implementation of individual inverter units and the operating requirements at the single point of interconnection (POI).

However, given the increasing penetration level of IBRs in modern power grids, **converter systems** should also be taken into account to meet the grid needs in a wider area. All the emerging criteria call for a paradigm shift into a power-electronics-intensive power system in the areas of dynamic modeling and control, advanced hardware testing, as well as industrial standardization. In this tutorial, the diversified and multi-disciplinary instructor team from academia and government national laboratories will introduce the latest research advances and industry practices on grid-interactive power electronic inverters, highlighting dynamic modeling and control, large-scale hardware-in-the-loop validation, full-scale hardware testing in both normal and fault conditions, and also the legacy and emerging industrial standardization.

The topics will range from fundamental concepts covering the necessary background knowledge to advanced applications and field deployment. Further, a hierarchy of topics covering individual inverters (grid-forming and grid-following), inverter clusters (hybrid AC and DC microgrids), 1 MW full-scale hardware test-bed (NREL 1 MW grid-forming test facility), and very-large-scale power systems with high penetration of inverters (Western Electricity Coordinating Council [WECC] network) will be introduced with the complementary capabilities of the instructor team. The tutorial serves to share the latest research progress and industry practice of grid-interactive power electronics and covers a broad audience group, including universities, inverter vendors, utilities, and government national laboratories.

It is noteworthy that the tutorial will be designed as an **interactive session** for boosting audience interest and participation. Particularly, the interactive tutorial session will be implemented by inviting the audience to access the interactive tools and video tours during the tutorial to dive into the demo with real-world scenarios and applications.

Instructor Biography

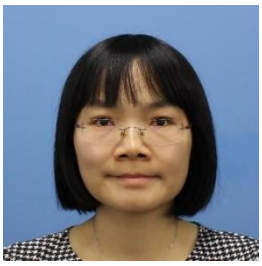


Xiaonan Lu received his B.E. and Ph.D. degrees in electrical engineering from Tsinghua University, Beijing, China, in 2008 and 2013, respectively. From September 2010 to August 2011, he was a guest Ph.D. student at the Department of Energy Technology, Aalborg University, Denmark. From October 2013 to December 2014, he was a Postdoc Research Associate at the Department of Electrical Engineering and Computer Science, University of Tennessee, Knoxville. From January 2015 to July 2018, he was with the Energy Systems Division, Argonne National Laboratory, first as a Postdoc Appointee and then as an Energy Systems Scientist. From July 2018 to July 2022, he was with the College of Engineering at Temple University as an Assistant Professor. In August 2022, he joined the School of Engineering Technology at Purdue University as an Associate Professor. His research interests include modeling, control, and design of power electronic inverters, hybrid AC and DC microgrids,

and real-time hardware-in-the-loop simulation. Dr. Lu is the Associate Editor of IEEE Transactions on Industrial Electronics, the Associate Editor of IEEE Transactions on Industry Applications, the Editor of IEEE Transactions on Smart Grid, and the Editor of Power Engineering Letters. He serves as the Chair of the Industrial Power Converters Committee (IPCC) in the IEEE Industry Applications Society (IAS). He is also the recipient of the 2020 Young Engineer of the Year Award in the IEEE Philadelphia Section.

Wei Du received his Ph.D. in Electrical Engineering from Tsinghua University, Beijing, China in 2014. His main areas of research are control design, modeling, and simulation of power systems with high penetration of power electronics devices. He is currently a staff research engineer at the Pacific Northwest National Laboratory and serves as the Principal Investigator for multiple DOE projects that focus on studying the impacts of high penetration of inverter-based resources on the transient and dynamic behaviors of power systems at different scales. Dr. Wei Du has a mixed industry and academic background. Prior to joining PNNL, he worked as a post-doctoral Research Associate at the University of Wisconsin-Madison from 2016 to 2018. He also worked as a Research Engineer at the key power system Real Time Digital Simulation (RTDS) lab of China Southern Power Grid Company from 2014 to 2016.

Mariko Shirazi received her B.S. degree in mechanical engineering from the University of Alaska, Fairbanks (UAF), in 1996 and her M.S. and Ph.D. degrees in electrical engineering from the University of Colorado, Boulder, in 2007 and 2009 respectively. From 1996 to 2004, she was at the National Renewable Energy Laboratory's (NREL's) National Wind Technology Center, where she was involved in the design and deployment of wind-diesel hybrid power systems for village power applications. From 2009 to 2017, she was with the Power Systems Engineering Center, NREL, where she was involved in the design and construction of power electronics for microgrid applications and was also detailed for two years to assist with the design and commissioning of NREL's Energy Systems Integration Facility. Mariko currently serves as the University of Alaska's President's Professor of Energy, at the Alaska Center for Energy and Power, UAF. She is interested in bridging power electronics and power systems research to understand the performance of converter-dominated power systems.



Jing Wang is a Senior Research Engineer at the National Renewable Energy Laboratory, where she has worked for the past five years. She received her Ph.D. degree in electrical engineering from RWTH, Aachen University in 2015. From 2015 to 2017, she worked as a lead power system engineer at GE Grid Solutions in Stafford, UK, and she led multiple microgrid grid automation projects and HVDC system validation projects. Her research focuses on power electronics control of distributed energy resources (DERs), microgrid modeling, protection design, and DER control and integration. She has expertise in power and controller hardware-in-the-loop (HIL) evaluation of microgrid controllers, advanced distribution management system (ADMS), distributed energy resource management system (DERMS) for grid automation and control, and DER integration studies. Especially, she leads the 1 MW multi-vendor demo for the SETO-funded UNIFI consortium.

Christopher Rowe is the R&D and Microgrid Control Specialist at Enphase Energy. He completed a Ph.D. in Advanced Power Frequency Droop Control at the University of Newcastle, Australia. He has worked at a number of companies and in renewable technologies that vary from the Grid Scale to C&I and residential. He has designed microgrids and has industrial expertise on a number of microgrid controllers. Notably he is listed as a co-inventor on many of the Enphase IQ8 grid-forming microinverter patents and was a facilitator of the microgrids group for IEEE Std 1547.