

## Data-Driven Cyber-Physical Resiliency of the Electric Grid

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Information and communication technologies enable to realize the smart grid vision but also bring vulnerabilities. It is important to analyze the impact of possible cyber-attacks on the power grid and develop defense mechanisms. Cyber-physical security analysis needs to be performed to minimize the impact of the potential cyber attacks on the power grid. Keeping the power on to critical facilities such as hospitals and fire department during cyber events is essential. There is a need for formal metrics to quantify resiliency of the electric grid, or different configurations of the same network. Number of resources are available with integration of microgrids and DER to improve the resiliency of the critical loads during cyber-attacks and grid disturbances. Additionally, sensor data availability such as smart meters, phasor measurement units and cyber data as well as weather data makes it possible to do resiliency analysis with enhanced situational awareness. This tutorial will cover basic of cyber infrastructure for the power grid, cyber vulnerabilities, common vulnerabilities and exposures (CVE) score, recent cyber attacks against the power grid, cyber-physical security analysis, defining resiliency, and a tool to study the cyber-physical resiliency of the electric grid.



Anurag K. Srivastava is an associate professor of electric power engineering at Washington State University and the director of the Smart Grid Demonstration and Research Investigation Lab (SGDRIL) within the Energy System Innovation Center (ESIC). He also has a joint appointment as a Senior Scientist with the Pacific Northwest National Lab (PNNL). He received his Ph.D. degree in electrical engineering from the Illinois Institute of Technology in 2005. In past years, he has worked in different capacity at the Réseau de transport d'électricité in France; RWTH Aachen University in Germany; PEAK RC, Idaho National Laboratory, Pacific Northwest National Lab, PJM Interconnection, Schweitzer Engineering Lab (SEL), GE Grid Solutions, Massachusetts Institute of Technology and Mississippi State University in USA; Indian Institute of Technology Kanpur in India; as well as at Asian Institute of Technology in Thailand. His research interest includes data-driven algorithms for power system operation and control including resiliency analysis. Dr. Srivastava high impact research projects resulted in tools installed at the utility control center supported for more than \$50M by US Department of Energy, National Science Foundation, Siemens Corporate Research, Electric Power Research

Institute, Schweitzer Engineering Lab, Power System Engineering Research Center, Office of Naval Research and several National Labs. He is a senior member of the IEEE, vice-chair of the IEEE Power & Energy Society's (PES) PEEC committee, co-chair of the microgrid working group, secretary of power system operation SC, chair of PES voltage stability working group, chair of PES synchrophasors applications working group, past-chair of the IEEE PES career promotion subcommittee, past-chair of the IEEE PES student activities committee, and past vice-chair of the IEEE synchrophasor conformity assessment program. He organized NSF sponsored "Data analytics workshop for the power grid resiliency" in 2018, Siemens sponsored "data analytics for the smart grid" workshop in 2017, North American Power Symposium in 2014, and IEEE sponsored workshop on Testing and validation of synchrophasor devices and applications in 2012. He also co-organized Workshop on "Modeling and simulation of Cyber-Physical Energy Systems" supported by IEEE and IES in 2016, 2017, 2018 and 2019. Dr. Srivastava is an editor of the IEEE Transactions on Smart Grid, IEEE Transactions on Power Systems, IEEE Transactions on Industry Applications, and Elsevier Sustainable Computing. He is an IEEE distinguished lecturer and has delivered 30+ keynotes/ tutorials in more than 15 countries. He is author of more than 300 technical publications including a book on power system security and 3 patents.