

Srijib Mukherjee, PhD, PE

Personal summary

Education:

MBA, Duke University, The Fuqua School of Business, NC, 2004

PhD, University of Miami, Coral Gables, FL, 1994

MSEE, University of Miami, Coral Gables, FL, 1991

BE, Mangalore University, Karnataka, India, 1989

Registrations:

Professional Engineer

NC #26216

CA #16264

NERC Certified System Operator, #N19981282

Professional memberships:

Accreditation Board of Engineering Technology (ABET), Program Evaluator, 2012-Present

University of Miami, College of Engineering, Industry Advisory Board, 2012-Present

NC State University, FREEDM Center, Education Advisory Board, 2010-2014

Duke University, Professional Member, Engineering World Health, 2008-Present

Duke University, Fuqua Alumni Council Member, 2004-2009

Duke University, Alumni Admission Advisory Committee, 2003-Present

IEEE Easter NC Industrial Applications Society, Chair, 2001-2002

IEEE Senior Member, 1999

Tau Beta Pi, Life Member, 1989

Eta Kappa Nu/HKN, Life Member, 1990

Years in practice:

27

Dr. Mukherjee is an expert in US energy markets, electric vehicle battery storage technology, regulatory policy surrounding autonomous cars, energy storage, power system operations, interconnected grid operations, distributed generation of power systems, microgrids, and energy trading & risk management. He brings over 27 years of experience from the electric utility (Duke Energy, NV Energy, NextEra Energy) and energy consulting industries in interconnection studies, day ahead market analysis, energy storage, energy risk management strategy, power system operations, distributed generation of power systems, NERC compliance, and generator siting and interconnection studies for wind, solar and other generator interconnections. Dr. Mukherjee has led teams in power dispatch operations, regulatory policy, energy risk management, resource & transmission planning and energy trading/portfolio management. Srijib is an expert in developing renewable assets for energy market participation within ERCOT, PJM, CAISO, MISO, NYISO and ISO NE. He has an excellent understanding of EV infrastructure planning, Day Ahead Energy Markets (DAM), Day Ahead Ancillary Services markets and the real time energy market. He is proficient in the use of security constrained economic dispatch or SCED software packages such as ABB Ventyx, Powerbase/PROMOD and GE- MAPS for doing market and LMP analysis. Additionally, he has developed, streamlined and standardized various control center applications in relation to building Control Center Organizations, Regional Transmission Organizations (RTO) and Independent System Operator (ISO) organizations, and helped structure and build metrics to bring profitability.

Dr. Mukherjee also teaches an undergraduate and graduate level class at the University of North Carolina at Charlotte on US Energy Markets to Electrical Engineering, Systems Engineering and Business school students.

Employment history

2019 - Present	Sr. R&D Scientist, Oak Ridge National Laboratory
2018 – 2019	Principal Engineer, Mott MacDonald Inc.
2014 – 2018	Principal Engineer, Pike Electric Company
2013 – Present	Adjunct Professor, University of North Carolina at Charlotte
2006 – 2014	Director, Quanta Technology, a Quanta Services Company
1999 – 2006	Senior Engineer, Duke Energy
1994 – 1999	Engineer, NV Energy/Sierra Pacific Resources
1991 - 1992	Summer Intern, NOAA Miami, FL
1989 – 1990	Summer Intern, Florida Power & Light Company

Mentored and Mentoring Students (past 5 years)

1. Duncan Clark, Senior Supply Chain Analyst, Duke Energy Corporation, Charlotte, Systems Engineering/MBA, UNCC, 2015
2. Max Ferrari, ORNL, Power and Energy Division, Bredesen Center Student, wants to put me on this Thesis Committee, Dec 2019 – Pr.
3. Adeniyi (Abi) Abeniyi, ORNL, Reactor and Nuclear Division, will be doing his Thesis under me. Entering Bredesen Center Ph.D. student, Dec 2019 – Pr.
4. Sambidh Timilisia, Graduate, Masters of Management Science, Duke University, Fuqua School of Business, 2018 – Present
5. Matt Gosnell, Engineer, Pike Electric Company, University of Virginia, NC State University, Master's Thesis committee
6. Willis Edmondson, Engineer IV, Mott MacDonald, NC State University, FREEDM Center, Masters and Ph.D. mentor

** Phone numbers for these students can be furnished upon request

Google Scholar Citations

<https://scholar.google.com/citations?user=PHVZNR0AAAAJ>

Orcid publications

<https://orcid.org/my-orcid>

Publons publications

<https://publons.com/researcher/3460996/srijib-mukherjee/>

ORNL Web Page

<https://www.ornl.gov/staff-profile/srijib-k-mukherjee>

Accreditation Board of Engineering Technology ABET Program Evaluator History

- a. Washington University in St. Louis, IEEE EAC, Electrical Engineering
- b. Florida Institute of Technology, Melbourne, FL, IEEE EAC, Electrical Engineering
- c. University of South Florida, Tampa, FL, IEEE EAC, Electrical Engineering
- d. Wentworth Institute of Technology, Boston, MA, IEEE EAC, Electrical Engineering
- e. University of Hail, Hail, Saudi Arabia, IEEE EAC, Electrical Engineering
- f. Bethel College, Eden, MN IEEE EAC, Electrical Engineering

Awards and Nominations

- Alternate Board Member IEEE Committee on Engineering Accreditation Activities
- Duke University, Fuqua Alumni Council
- NC State University, FREEDM, Education Advisory Board
- Manipal University, Distinguished Alumnus Award, 2014
- Quanta Technology, Service Award for Exceptional Dedication, 2011
- IEEE, Power Engineering Society Outstanding Engineer, 2001
- IEEE, PICA System Restoration contest winner, 1999
- IEEE, Senior Member, nominated in 2001
- Inducted into Tau Beta Pi Engineering Honor Society (Florida Beta), 1989
- Inducted into Eta Kappa Nu Electrical Engineering Honor Society, 1990

Publications:

1. Sticht C., Mukherjee S., Efficient Coordination of Sequential Reclosers on Distribution Feeders (Fan Curve Philosophy), submitted to IEEE PES Open Access Journal, Apr 2020
2. Mukherjee S., Langholtz M., Feedstock and logistics options toward bioenergy with carbon capture and sequestration (BECCS) in the US, Journal Paper, TBD
3. Mukherjee S., Frequency Response and Dynamic Power Balancing in Wind & Solar Generation, TSDOS Conference, Dallas, TX 2019
4. Edmondson Willis., Mukherjee S., "Adaptive Capacitor Switching for Wind Generation" AWEA Wind Power Conference, Houston, TX, May 20-23, 2019
5. Edmondson Willis., Mukherjee S., "Adaptive Capacitor Switching for Wind Generation" IEEE IAS General Meeting, Cincinnati, OH, Jul. 2017
6. Mukherjee S., "Applying the Distribution System in Grid Restoration/NERC CIP-014 Risk Assessment" IEEE Rural Electric Power Conference, May 2015

7. Mukherjee S., Vermeer D., "Macro Economic Impacts of Electric Vehicles in the United States", Scientific America Article in collaboration with the Center for Energy, Development, and the Global Environment (EDGE) at Duke University, Nov. 2012 – Work in Progress article
8. Mukherjee S., Gentile T., Morrow D., Kruimer B., Large scale renewable energy integration. Recent experiences in the USA, US DOE Office of Scientific and Technical Information, July 2012
9. Mukherjee S., Casteneda J., Wind Storage Enhanced Transmission Research and Development: Final Project Report, California Energy Commission, 2012
10. Mukherjee S., Teleke S., Bandaru V. "Frequency and Dynamic Power Balancing in Wind and Solar Generation", IEEE PES, General Meeting, Detroit, Jul. 2011
11. Mukherjee S., Variable Generation Forecasting, NERC IVGTF 2.1 Report, May 2010
12. Mukherjee S., Teleke S., Bandaru V. "Dynamic Power Balancing in Wind Generation", GridTech 2011 proceeding, pp.411, New Delhi, India
13. Wojszczyk B., Mukherjee S., Morrow D., "Massive Deployment of Wind Generation: Dynamics and its Impact on Power Grid Operations", IREP 2007, SC, Aug. 2007
14. Mukherjee S., "Screening of Load Patterns and Transmission Planning Alternatives using Decision Trees", IREP 2007, SC, Aug. 2007
15. Mukherjee S., Wilson P. "Training Curriculum for System Dispatchers", T&D Magazine, May 1995
16. Mukherjee S., Lindquist C., "A Homomorphic Approach to Digital Companding", 28th Annual Asilomar Conference on Signals, Systems and Computers. Nov. 1994, Naval Postgraduate School, Monterrey, CA
17. Mukherjee S., Recio A., "Voltage Monitoring using Power Flow Applications", IEEE, Southeastcon, 1992

Selected projects

ERCOT West Wind Transfer Capability Study (Direct Energy, LP): Led a project to determine transfer capability limits from the West to the North, South and Houston market zones of ERCOT and provided short term system improvements, implementable in 12 to 18 months to allow for increased transfer capability from the West to the North zone. Recommended practical solutions using ERCOT's planning criteria and operating guides to determine possible system reconfiguration, reactive series elements, reconducting of transmission lines, terminal/substation equipment replacement, special protection systems (SPS), optimal reactive dispatch, wind power integration issues, FACTS devices, real time equipment monitoring and ratings criteria.

National Grid Five Year Statement: Provided expert advice related to the NGRID Generation and Transmission Five Year Statement: These services included using GE-MAPS to model requests in the OASIS interconnection queue (primarily Wind & Thermal units) and simulate the 2012 average area Locational Marginal Prices (LMP's) for New York (NY) and New England (NE). In addition to finding the combined peak hour demand for NY and NE's constrained and unconstrained 2008 and 2012 built cases. Performed market assessment and helped site new generation within NE and NY (specifically Wind and Thermal Units) and other transmission projects along with the upgraded interface transfer limits

Wind Storage Enhanced Transmission R&D, Southern California Edison: A project team led by Southern California Edison analysed Southern California Edison's electric system to identify interconnection locations that would benefit from integrating energy storage technologies. The team investigated system contingencies and possible wind storage impacts on the system. Battery Storage and converter manufacturers were selected using the Request for Information Process. After determining which manufacturers could provide the best technology for implementation, the team selected the battery storage devices that satisfy the criteria for providing promising, commercially viable, economically feasible, and scalable

solutions, The team also provided a pathway for commercialization as a well as a technology transfer plan. The implementation of energy storage devices into the Southern California energy grid helped California meet its renewable portfolio or RPS goals of 33% of electricity coming from renewable resources by 2020, which will reduce greenhouse gas emissions and other air emissions that contribute to air pollution. Dr. Mukherjee was an author on the published report to the California Energy Commission (CEC)
(<https://www.energy.ca.gov/2013publications/CEC-500-2013-044/CEC-500-2013-044.pdf>)

USTDA North Delhi Power Limited Smart Grid Project: The objective of this USTDA grant was to prepare a smart grid roadmap for North Delhi Power Limited (now called Tata Power Delhi Distribution Limited/TPDDL). This included developing a comprehensive plan for implementing smart grid and intelligent control throughout TPDDL's distribution system based on the previous smart grid feeder pilot project. The project assessed the technological, economic, regulatory support and financial aspects of scaling up from the pilot project to other feeders on the TPDDL system.

Frequency Response and Dynamic Power Balancing with High Concentrations of Renewables, Southern California Edison (SCE): The main objective of this project was to develop mitigation strategies necessary to ensure appropriate load balancing and ACE/Frequency regulation. The primary benefit was the development of dispatch strategies that enabled SCE to maintain compliance with mandatory NERC and WECC Reliability Standards for regulating performance. Another significant benefit of this project was improved insights into generation resource planning. The project identified ramp rate considerations as a new factor to consider when evaluating the need for supplemental generation. Insights were provided for SCE resource planners to cost-effectively address this need in the SCE generation resource portfolio.

Energy Water Authority (EWA) Bahrain (present ongoing): Lead Engineer with the Mott MacDonald Abu Dhabi, UK and South Africa offices to conduct line outage and energisation studies, protection coordination studies, energisation studies for the new 400 kV substations and cables. Liaison and communication with internal stakeholders.

Electricite D'Haiti (EDF) Transmission Pre-Evaluation Assessment: The purpose of this project was to perform a pre-evaluation assessment of the current state of the T&D system and utility operations located in the Republic of Haiti to determine the types of system and utility information and data that are available, perform a site visit to gain an overall perspective of the power system and utility operations and conduct interviews with key utility management and operations personnel. The results of this assessment were used to determine, at a high-level, system deficiencies and opportunities for improvements and to make any recommendations for further investigations, assessments and studies.

The on-site evaluation was utilized to determine the current state of the system, including but not limited to the areas of:

- Capacity Injection – including the need for generation interconnection studies
- Reliability and Deliverability of any proposed generation to the grid
- Availability and Power Transfer within the existing T&D infrastructure
- Condition of equipment and infrastructure
- Use of SCADA and other forms of automation
- Mitigating strategies to improve system losses

Georgia Transmission, Smarr Interconnection and Transmission Service Request (TSR) Study: Project Manager and lead for this two-unit combined cycle unit interconnection feasibility study in central Georgia. Work included performing thermal and voltage analysis sensitivities for several years using steady state PSS/E, interface analysis for first contingency incremental transfer (FCITC) to interfaces using PSS/E MUST, stability analysis for critical clearing time for single and three phase faults and closing angle analysis using PSS/E dynamics, bus ampacity analysis and a reactive requirement study.

Georgia Transmission Asset Review (System Impact Study), Progress Ventures Inc.: Led and worked with a team of consultants to analyze transmission constraints that affects Progress Ventures Inc. (PVI), Georgia Assets – specifically interconnection of Effingham CT (merchant asset) from the 230 kV to 500 kV systems. Analyzed what transmission constraints affect PVI's Georgia assets, the ability to deliver power to customers in the region, how these constraints are likely to change over 10 years and how it impacts revenues and operations. Also, recommended transmission upgrades that would affect the deliverability of power. Produced value at risk (VaR) solutions of assets under alternate market development scenarios.

Commonwealth of Massachusetts Reliability Studies: The focus of this study was to perform a standard steady state analysis of National Grids system in New York and New England to confirm that there are no thermal or voltage violations within the MA service area of National Grid. This was a typical deterministic N-1 contingency analysis study complying with NERC planning standards criteria (A, B and C) and NPCC planning study criteria (A1 and A2). Studies were performed using PTI PSS/E v.30 for system intact analysis (base case) and PTI MUST for contingency analysis.

Southwest Power Pool (SPP) EHV Overlay Project: The focus of this project was to conduct long range strategic assessment regarding long-term reliability and economic needs of a 345 kV, 500 kV, and 765 kV or higher transmission system to overlay of the SPP footprint. Study also performed a market assessment of wind farm siting and transfer capability between SPP and its neighbouring systems.

MAPP Reliability Standards Compliance Practice Audit/Gap Analysis: Conducted a practice audit for MAPP to assess whether MAPP staff responsible for each applicable standard is adequately prepared to answer questions and provide documentation in an MRO Audit Packet, and during an on-site audit. Identified any potential gaps and recommended remedial actions as to related applicable standards or MAPP procedures. Assisted MAPP staff to be prepared to demonstrate compliance with all applicable standards that may appear on the 2009 audit.

Apex Wind Energy Solar Farm TRV and TOV Studies: The principal objective for the overvoltage studies at various solar farms involved evaluating the effectiveness of high speed inter-locked circuit breaker/ground switch on feeders to reduce resulting transients and temporary overvoltage's during fault conditions. Surge arrester sizing ratings were modelled to see if it was within acceptable ranges. Transient models of the solar farms were built using the EMTP – RV simulation program. The Transient Recovery Voltage studies involved modelling transient limiting inductors to limit transient current during switching (in-rush) and close in faults (out rush), specifically modelled between the substation capacitor and the capacitor switching device.

Duke Energy, Substation Grounding Projects: Principal Project Reviewer for several Duke Energy substation ground grid designs for adequate step and touch potentials within the substation as recommended by IEEE 80-2000. This involved work performed using the CDEGS software.

Investigation of the transmission impacts of wind turbine blade failures and modelling of blade setback distances for wind farms within Pacific Gas & Electric (PG&E): The main goal of the investigation was to calculate the setback distances of wind turbines from specific wind farms. Additionally, to model and calculate applicable clearance distances using aerodynamic and probabilistic models to minimize the system impacts during blade, tower or turbine failures.

PSEG CIP-2 Risk Based Asset Methodology (RBAM) Analysis: Three objectives of this project:

- Evaluated PSEG's in-house methodology for determining critical assets with respect to the NERC CIP-002 requirements for fossil plants;
- Reviewed the regional system restoration plans and black-start expectations of the PSEG fossil plants; and
- Performed a steady state power flow RBAM analyses to determine whether there are any critical assets among PSEG's fifteen (15) fossil plants in New Jersey, New York, Connecticut and Texas

Power Plant Organizational Design Audit, PSEG Fossil, LLC: Development of PSEG Power Program Roadmap Development of PC-FOS-409 (Roadmap for various PSEG Internal Procedures). Reviewed PSEG Nuclear Procedures. Additionally, reviewed PSEG, Fossil CMEP Program (Self Certifications, Spot Checking, Compliance Violation investigations, self-reporting, periodic data submittals, exception reporting and complaints).

NV Energy/Sierra Pacific Resources, Energy Supply Resource Procurement: Recommended strategies to minimize business risk for regulatory, stakeholder, energy supply, process and credit risk for the Enterprise Trading & Risk Management organization. This included addressing exposure to short term portfolio optimization, spot market trading, short term forward markets and other front, middle and back office functions on the SPR trading floor. Advised the Senior Vice President, Energy Supply on the organizational strategies with respect to reporting relationships, talent needs, environment, climate, culture, leadership, procedures, controls, investments/costs and technology.

BG&E/Constellation Energy NERC ERO Program Development: Provided expert advice to BG&E on financial risk exposures associated with non-compliance of applicable NERC standards. Expert advice on organizational and strategic challenges and regulatory policy issues surrounding the building of a corporate compliance program with respect to ERO and RRO standards and helped create a Program Manual and a cross functional Program Manager that has reporting responsibilities on ERO compliance issues from executive management to legal and line organizations.

Calpine NERC ERO Compliance Project: Provided management and executive advising to help prepare for a NERC audit (specifically pre-audits for Calpine power plants within SERC, WECC and ERCOT). Assisted in entity assessment. Developed compliance procedures, compliance roll out processes and created roadmaps. Established internal processes, protocols and record keeping systems to achieve auditable compliance with the applicable regulatory approved standards

Direct Energy ERCOT RRO Pre-Audit Assessment: Performed a pre-audit for Direct Energy, LP power plants within West Texas. Helped executives understand financial exposures and performed remediation to mitigate risks to the non-compliance gaps that were identified.