ELECTRIC POWER RESEARCH INSTITUTE

GEARED

GridEd

The Center for Grid Engineering Education

Distributed Generation Technologies and Applications

Course Description

This course is one in a series of several courses developed and offered by GridEd to address the evolving forces that will alter the fundamental operating characteristics of the electric grid, transforming it from a one-way central supply structure to one that has bidirectional power flows resulting from distributed energy resources (DER). Self- generating consumers will alter the design requirements for the electric distribution system. This course focuses on distributed generation technologies and applications. The operation and applications of distributed generation technologies for utility applications will be explored. The course content spans not only how these technologies work but also the history of their development and use and the benefits that DER can bring to generation requirements; transmission and distribution systems; microgrids; and off-grid applications. Participants will also learn about the technical challenges facing the wider use of DER and what can be done to address those challenges.

Who Should Attend

The course is intended for anyone interested in the opportunities to incorporate distributed generation into the grid and how these technologies will change the way the grid works. Participants will include utility engineers and technicians, procurement officers, regulatory compliance staff, legal staff, and possibly regulators. Previous technical training is helpful but not necessary.

Registration Information

PDH Available: 12 hours

Registration Fee:

- $1,200 per person
- 20% discount for organizations with three or more attendees
- 25% discount for government employees (non-utility)
- 25% discount for university professors*
- 75% discount for graduate students*

*University IDs required to qualify for professor or graduate student discounts.

Students need to bring: laptops or tablets to access online resources and to follow class notes. Wi-Fi access is provided. Lecture slides will be provided electronically in PDF format.

For More Information

Amy Feser, afeser@epri.com, (865) 218-5909

Course Instructors

Badrul Chowdhury, b.chowdhury@uncc.edu, (704) 687-1960

Babak Parkhideh

Dr. Abasifreke Ebong

Meet the Instructors

Badrul Chowdhury is a Professor with a joint appointment in the departments of ECE and SEEM at UNC Charlotte. His research interests are in power system modeling, analysis, control and economics; energy markets; complex multi-modal non-linear system vulnerability assessment; integration of renewable and distributed energy resources including wind electric conversion systems, solar PV, fuel cells, and energy storage in a smart grid environment; Microgrid control and optimization. Prior to joining UNC-Charlotte, he was a Professor in the ECE Department of Missouri S&T. He has published more than 150 papers in archival journals and conference proceedings. Dr. Chowdhury has also directed more than 40 Ph.D. and M.S theses in these areas. He is an Editor for the IEEE Transactions on Sustainable Energy, IEEE Power and Energy Letters, and the International Transactions on Electric Energy Systems. Dr. Chowdhury is a Senior Member of the IEEE, Chowdhury received his PhD degree in electrical engineering from Virginia Tech.

Babak Parkhideh is an Assistant Professor in the Electrical and Computer Engineering department at the University of North Carolina-Charlotte. His research interests are utility applications of power electronics and real-time modeling, analysis and control of smart grid. In the past two years, Dr. Parkhideh has been leading a team at UNC Charlotte to develop and commercialize a PV inverter architecture that eliminates the electronic footprints and optimizes the balance of system. The program is currently sponsored by the US DOE SunShot Initiative Incubator Program. Dr. Parkhideh completed his Ph.D. (2012) and M.Sc. (2007) in Electrical Engineering at North Carolina State University, Raleigh and RWTH-Aachen University, Germany, respectively. Dr. Parkhideh has published more than 45 papers in archival journals and conference proceedings in the broad areas of power electronics.

Dr. Abasifreke Ebong, a Professor at University of North Carolina at Charlotte, holds a PhD degree in Electrical and Computer Engineering with specialty in Photovoltaic Devices and Technologies. Professor Ebong had his post-doctoral experience at Samsung Electronics in South Korea before joining the University Center of Excellence for Photovoltaic Research (UCEP) at Georgia Tech in 1997. After four years at UCEP, Professor Ebong joined GE Global Research Center as engineer, working on LED, for three years before rejoining UCEP as the Assistant Director in 2004. He joined the Department of Electrical and Computer Engineering at full Professor in 2011. He has developed highly efficient crystalline silicon solar cells in the lab and guided technology transfer to manufacturing lines. He is directing the Photovoltaic Research Laboratory (PVRL) infrastructure at UNC Charlotte. He has published more than 120 journal and conference papers with over 130 co-authors worldwide. Ebong obtained his PhD from the University of New South Wales in Australia in 1995.

Course Outline

Day 1

- **Introduction to the course on Renewable and Distributed Energy Systems**
  - Changing landscape of the power industry
  - Current state of RDES on the power grid
  - What is driving the change?
- **Distributed Generation with Fossil Fuels**
  - Microturbines
  - Reciprocating internal combustion engines
  - Stirling engines
- **The Solar Resource**
  - Solar geometry
  - Direct-beam radiation
  - Diffuse radiation
  - Reflected radiation
  - Tracking systems
  - Problem solving
- **Photovoltaic Materials and Electrical Characteristics**
  - Basic semiconductor physics
  - Equivalent circuit of a PV cell
  - I –V curve under standard test conditions
  - Impacts of temperature and insolation on I –V curves
  - Shading impacts on I–V curves
  - Crystalline silicon technologies
  - Thin-film photovoltaics
  - Other types of cells
- **Concentrating Solar Power (CSP) Technologies**
  - Solar dish/Stirling power systems
  - Parabolic troughs
  - Solar central receiver systems
  - Problem solving
- **Photovoltaic Systems**
  - PV Inverter systems (DC to AC conversion)
  - Balance of systems
  - Residential, commercial and utility-scale
  - Monitoring of PV systems
  - Smart Inverters

Day 2

- **Fuel Cells**
  - Basic operation of fuel cells
  - Fuel cell thermodynamics
  - Electrical characteristics
  - Types of fuel cells
  - Hydrogen production
- **Wind Power Systems**
  - Wind turbine generator types
  - Speed control
  - Wind power probability density functions
  - Wind farms
  - Problem solving

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