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

- **Class Dates:**
  - Live In-Person: August 25th & 26th, 2015
    - Day 1: 8:00 a.m. – 6:00 p.m. ET
    - Day 2: 8:00 a.m. – 3:00 p.m. ET
  - Feedback Session (for those taking recorded course online*):
    - Live 1-hr Webcast, September 11, 2015
      - 11:00 a.m. – 12 p.m. ET

- **Course Length:** 1.5 Days
- **PDH Available:** 12
- **Registration Fee:**
  - $1,200 per person
  - 20% discount for organizations with three or more attendees
  - 25% discount for university professors**
  - 75% discount for graduate students**

- **Location:**
  - UNC – Charlotte
  - EPIC Building, Room 1332
  - 9201 University City Blvd.
  - Charlotte, NC 28223

*Online: Participants who are unable to attend in person can view the recorded sessions. However, those choosing this option will be required to participate in a live, 1-hr webcast on September 11, 2015 where they will have the opportunity to interact with instructors, get feedback and summarize learning.

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

Registration: [http://grided.epri.com/courses.html](http://grided.epri.com/courses.html)

*Students will need:* A laptop computer with internet connection capability.

Contacts

- **Badrul Chowdhury, UNCC**, [b.chowdhury@uncc.edu](mailto:b.chowdhury@uncc.edu) or 704. 687.1960
- **Lori Warneke, EPRI**, [lwarneke@epri.com](mailto:lwarneke@epri.com) or 865.218.8174

*Professional Development Hours*
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 has published more than 45 papers in archival journals and conference proceedings in the broad areas of power electronics.

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. Abasifeke Ebong is a Professor at University of North Carolina at Charlotte and 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 as 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

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?

2. **Distributed Generation with Fossil Fuels**
   - Microturbines
   - Reciprocating internal combustion engines
   - Stirling engines

3. **The Solar Resource**
   - Solar geometry
   - Direct-beam radiation
   - Diffuse radiation
   - Reflected radiation
   - Tracking systems
   - Problem solving

4. **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

5. **Concentrating Solar Power (CSP) Technologies**
   - Solar dish/Stirling power systems
   - Parabolic troughs
   - Solar central receiver systems
   - Problem solving

6. **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

7. **Fuel Cells**
   - Basic operation of fuel cells
   - Fuel cell thermodynamics
   - Electrical characteristics
   - Types of fuel cells
   - Hydrogen production

8. **Wind Power Systems**
   - Wind turbine generator types
   - Speed control
   - Wind power probability density functions
   - Wind farms
   - Problem solving