Power & Energy Training Series

April 2019

SG101

Introduction to Smart Grids

The introduction to smart grids course covers the basics of smart grids, the main difference between the smart grid and traditional grids, application of renewable energy generation sources in smart grids, and control of distributed energy resources (DERs), and energy storage technologies used in power generation systems. The course starts with an overview of smart grid systems and covers the standards and communication technologies applied to smart grids. Next, the challenges related to the power flow studies in smart grids and contingency analysis are covered.
Furthermore, the role of distribution system operators in smart grids is introduced and the demand response problem is discussed. Next, various types of renewable energy sources (e.g. solar or wind), electric vehicles, and energy storage devices used in smart grid systems are introduced and different control algorithms for each device is covered. Smart grid control is one of the most important challenges in modern smart grid systems. Therefore, in this training, various control algorithms applied to smart grid systems including grid-forming, grid-supporting, voltage/frequency, and droop control will be covered.

The course will also introduce the supervisory control and data acquisition (SCADA) system, smart monitoring systems, and phasor measurement units that are widely used in smart grid systems.

Training Participants

The introduction to smart grids is a 2-day course aimed to train:

- People of industry, government, or academia who are interested in understanding how the smart grid works and what are the concept behind it.
- Policy and legislation makers in the Government or state associated with electrical and power systems.
- Energy sectors of the government such as Deputy Assistant Secretary of the Navy-Energy; Air Force Installations, Environment & Logistics; Department of the Navy Energy Program for Security and Independence; Department of the Navy Strategy for Renewable Energy; Marine Corps Expeditionary Energy Office; Office of the Deputy Under Secretary of Defense, Installations and Environment; U.S. Army Office of Energy Initiatives (OEI); and U.S. Energy Information Administration.
- People involved in reviewing or writing research grants who need to be introduced to the concepts and components of smart grids.
- Operators and technicians of the power plants or utility companies, mostly entry- and mid-level.
- Non-technical personnel of the companies related to the electrical power system who need to have a basic understanding of smart grids, such as marketing people, financial officers or accountants, and executives.
- Individuals from solar, wind, and other renewable energy entities who are in the business of trading power.
- Students, scientists, faculty members, business owners, or freelance learners who are interested in smart grid training.

Course Objectives

Upon completion of the introduction to smart grid course, the participants will be able to:

- Learn the concept of smart grid
- Understand the communication system structure in smart grids
- Learn various measurement techniques used in smart grids
- Understand the load flow challenges in smart grids
- Recognize various types of control algorithms applied to smart grids
- Understand the cyber security challenges in smart grids
- Learn the standards used in smart grids
- Understand the operation of renewable energy sources in smart grids
- Apply various control algorithms to smart grid components
- Understand the contingencies in smart grids and techniques used for congestion management issue.

Course Outline

The following contents will be covered in the introduction to smart grid training course; however, they can be adjusted to the client's need:

Introduction to Smart Grid

- Introduction to power system operation
- Today's grid and the smart grid
- Energy independence
- Application of computational intelligence in smart grids
- Enhancing power system functionality by smart grids

- Communications in smart grids
- Standards in smart grids
- Interoperability and Standards
- Environmental impacts of smart grids

Smart Grid Communications and measurements

- Communication and measurements
- Phasor measurement units
- Smart meters
- Measurement technologies in smart grids
- Global information system (GIS)
- Google mapping tools
- Multi-agent systems (MAS)
- Microgrids

Smart Grid Analysis

- Load flow analysis
- Challenges to load flow in smart grids
- Classical and extended load flow methods
- Congestion management
- Optimal power flow in smart grids
- Security assessment in smart grids
- Contingencies in smart grids
- Contingency studies in smart grids
- Stability of smart grids
- Voltage stability problem in smart grids
- Steady state voltage stability
- Preventive control in smart grids

Advanced Smart Grids for Distribution System Operators

- NERC Requirements
- Reliability Consideration of Smart Grid
- Distribution System Operators (DSO)
- Balancing Supply and Demand by Distributed Energy Resources
- Integration of Renewable Energy Sources
- Demand Response
- Introduction to computational tools in smart grids
- Optimization techniques in smart grids
- Heuristic optimization in smart grids
- Adaptive dynamic programming
- Pareto methods
- Computational challenges in smart grids
- Adaptive control and optimization

Renewable Energy and Storage

- Renewable energy resources
- Solar generation
- Wind generation

- Energy storage in smart grids
- Penetration issue of renewable sources
- Sustainable energy options in smart grids
- Demand response issues
- Plug-in electric vehicle ((PEV)
- Plug-in hybrid electric vehicle (PHEV)
- Tax credits

Interoperability and Standards in Smart Grids

- Interoperability
- Standards in smart grids
- Smart grid cyber security

Smart Grid Control

- Control of solar generation
- Solar inverters
- Smart inverters
- Grid-forming control
- Grid-supporting control
- Droop control
- Virtual impedance control
- Voltage and frequency regulation
- Control of wind turbines
- Battery energy storage control
- Current control in inverters